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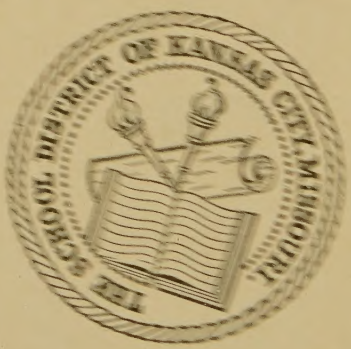

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THREE RECENT DECISIONS OF THE UNITED STATES SUPREME COURT, UPON VALUATION

BY LEONARD METCALF[1]

Three decisions of great importance to those interested in the valuation of public utility properties were handed down by the Supreme Court of the United States in May and June of the present year. They are generally referred to as the Southwestern Bell, the Bluefield Water Works, and the Georgia Railway and Power Company cases:

No. 158—October Term, 1922, handed down May 21, 1923

The State of Missouri ex rel. Southwestern Bell Telephone Company, Plaintiff in Error, vs. Public Service Commission of Missouri and John A. Kurtz, Edwin J. Bean, Hugh McIndoe et al., etc.	In Error to the Supreme Court of the State of Missouri

Mr. Justice McReynolds delivered the opinion of the Court. Dissenting opinion by *Mr. Justice Brandeis*, with whom *Mr. Justice Holmes* concurred.

No. 256—October Term, 1922, handed down June 11, 1923

Bluefield Water Works and Improvement Company, Plaintiff in Error, vs. Public Service Commission of the State of West Virginia et al.	In Error to the Supreme Court of Appeals of West Virginia

Mr. Justice Butler delivered the opinion of the Court. *Mr. Justice Brandeis* concurred in the judgment of reversal, for the reasons stated by him in No. 158 supra.

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[1] Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

No. 298—October Term, 1922, handed down June 11, 1923

Georgia Railway & Power Co. et. al., Appellants,
vs.
Railroad Commission of Georgia et al
} Appeal from the District Court of the United States for the Northern District of Georgia.

Mr. Justice Brandeis delivered the opinion of the Court. Dissenting opinion by *Mr. Justice McKenna.*

SOUTHWESTERN BELL TELEPHONE COMPANY DECISION—NO. 158

"The Supreme Court of Missouri (-Mo.-) affirmed a judgment of the Cole County Circuit Court which sustained an order of the Public Service Commission of Missouri, effective December 1, 1919. That order undertook to reduce rates for exchange service and to abolish the installation and moving charges theretofore demanded by plaintiff in error. It is challenged as confiscatory and in conflict with the Fourteenth Amendment."

"During the period of Federal control—August 1, 1918, to August 1, 1919—the Postmaster General advanced the rates for telephone service and prescribed a schedule of charges for installing and moving instruments. The Act of Congress approved July 11, 1919 . . . . directed that the lines be returned to their owners at midnight July 31, 1919" and that the existing toll and exchange rates should continue in force for a period not to exceed four months after the taking effect of the act, unless sooner modified or changed by the public authorities.

On August 4 the Commission directed the Telephone Company to show why the rates fixed by the Postmaster General should be continued, and after a hearing made report and directed that the service rates be reduced and the charges for installation and moving be discontinued.

The Company produced voluminous evidence, including its books, to establish the value of its property dedicated to public use. The books showed an actual cost of $22,888,943. Its engineers estimated the reproduction cost new at $35,100,868, and its existing value after allowing for depreciation, $31,355,675.

"The only evidence offered in opposition to values claimed by the Company, were appraisals of its property at St. Louis, Caruthersville and Springfield, respectively, as of December 1913, February 1914, and September 1916, prepared by the Commission's engineers and accountants, together with statements showing actual cost of additions subsequent to those dates."

The Commission found a "total adjusted original cost, $20,456,-621.33" and tentatively adopted the sum of $20,400,000 as the value of the property for the purposes of this case.

In a concise and significant opinion the Supreme Court reversed the decision of the lower courts.

In commenting upon the action of the Commission the court said "Obviously the Commission undertook to value the property without according any weight to the greatly enhanced costs of material, labor, supplies, etc., over those prevailing in 1913, 1914 and 1916. As a matter of common knowledge, these increases were large. Competent witnesses estimated them as 45 to 50 per centum." The Court then quoted from its past decisions, as follows:

"In *Wilcox v. Consolidated Gas Co.*, 212 U. S. 19, 41, 52, this Court said

> There must be a fair return upon the reasonable value of the property at the time it is being used for the public . . . . And we concur with the court below in holding that the value of the property is to be determined as of the time when the inquiry is made regarding the rates. If the property, which legally enters into the consideration of the question of rates, has increased in value since it was acquired, the company is entitled to the benefit of such increase.

"In *The Minnesota Rate Cases*, 230 U. S. 352, 454, this was said

> The making of a just return for the use of the property involves the recognition of its fair value if it be more than its cost. The property is held in private ownership and it is that property, and not the original cost of it, of which the owner may not be deprived without due process of law.

"See also *Denver v. Denver Union Water Co.*, 246 U. S. 178, 191; *Newton v. Consolidated Gas Co. of New York*, 258 U. S. 165 (March 6, 1922); and *Galveston Electric Co. v. City of Galveston*, 258 U. S. 388 (April 10, 1922).

"It is impossible to ascertain what will amount to a fair return upon properties devoted to public service without giving consideration to the cost of labor, supplies, etc., at the time the investigation is made. An honest and intelligent forecast of probable future values made upon a view of all the relevant circumstances, is essential. If the highly important element of present costs is wholly disregarded such a forecast becomes impossible. Estimates for to-morrow cannot ignore prices of to-day."

"Witnesses for the Company asserted—and there was no substantial evidence to the contrary—that excluding cost of establishing the

business the property was worth at least 25 per cent more than the Commission's estimates, and we think the proof shows that for the purposes of the present case the valuation should be at least $25,000,000."

With reference to the return, the Court found that after making a 6 per cent allowance for depreciation, which was accepted by the Commission, the rates yielded "a possible 5⅔ per cent return upon the minimum value of the property, which is wholly inadequate considering the character of the investment and interest rates then prevailing."

The amount (4.5 per cent of gross revenue) paid annually, by the Company to the holding company, the American Telephone & Telegraph Company, as rents for instruments and for licenses and services, under the form of contract customary between the latter company and its subsidiaries, was also at issue, as it has been before a number of State Commissions. Of this annual charge 55 per cent was disallowed by the Commission. With reference to it the Court found "There is nothing to indicate bad faith. So far as appears, plaintiff-in-error's board of directors has exercised a proper discretion about this matter requiring business judgment. It must never be forgotten that while the State may regulate with a view to enforcing reasonable rates and charges, it is not the owner of the property of public utility companies and is not clothed with the general power of management incident to ownership."

Thus the Court stood firmly in its decision on the ground previously taken "that the value of the property is to be determined as of the time when the inquiry is made regarding the rates;" and ruled that the Commission gave no weight to the greatly enhanced postwar costs, though "Estimates for to-morrow cannot ignore prices of to-day."

Southwestern Bell Telephone—No. 158—Minority Opinion

With this important decision in the Southwestern Bell Telephone Company Case (No. 158) there was handed down also a minority opinion written by Mr. Justice Brandeis and concurred in by Mr. Justice Holmes. It is an exceedingly interesting argument for radical change in method of evaluating public utility property. It is valuable chiefly as indicating the personal viewpoint of these justices, and voicing, perhaps more effectively than has yet been done, the viewpoint of the advocates of the "prudent investment theory."

It is important to note, however, that the views were not those of the majority of the Court, and it may well be doubted if the results desired would follow the procedure advocated.

Mr. Justice Brandeis says "I concur in the judgment of reversal. But I do so on the ground that the order of the state commission prevents the utility from earning a fair return on the amount prudently invested in it. Thus, I differ fundamentally from my brethren concerning the rule to be applied in determining whether a prescribed rate is confiscatory. The Court, adhering to the so-called rule of Smyth v. Ames, and further defining it, declares that what is termed value must be ascertained by giving weight, among other things, to estimates of what it would cost to reproduce the property at the time of the rate hearing." Mr. Justice Brandeis, on the other hand, holds that "The so-called rule of Smyth v. Ames is . . . . legally and economically unsound." Believing that "It is consistent with the Federal Constitution for this (U. S. Supreme) Court now to lay down a rule which will establish such a rate base and such a measure of the rate of return deemed fair" he proceeds to develop his theory of prudent investment cost, in the hope of establishing a rate base "definite, stable and readily ascertainable."

Mr. Justice Brandeis' view is based also upon the fundamental conceptions that "The thing devoted by the investor to the public use is not specific property, tangible and intangible, but capital embarked in the enterprise;" and that "Upon the capital so invested the Federal constitution guarantees to the utility the opportunity to earn a fair return (Footnote: except that rates may, in no event be prohibitive, exorbitant, or unduly burdensome to the public)."

The latter views are at variance with the past positions taken by the U. S. Supreme Court, and it is certainly a fact that under commission control corporations have not been guaranteed, nor have they at all times earned, a fair return.

The difficulties and uncertainties and the abuses of present methods of valuation of public utility properties are forcefully presented. "The experience of the 25 years since that case (Smyth v. Ames) was decided, has demonstrated that the rule there enunciated is delusive. In the attempt to apply it insuperable obstacles have been encountered. It has failed to afford adequate protection either to capital or to the public. It leaves open the door to grave injustice." He shows the divergent results obtained by the application of the different bases of valuation referred to in Smyth v. Ames and the

great differences resulting from different interpretations of existing law. He analyzes the practice of the commissions,—with respect to principles governing the valuation of public utility properties,—and indicates their drift toward the prudent investment theory (he might have added, despite repeated reversals by the higher courts), and how "the tendency developed, to fix as reasonable, the rate which is not so low as to be confiscatory. Thus the rule which assumes that rates of utilities will ordinarily be higher than the minimum required by the constitution, has by the practice of the commissions eliminated the margin between a reasonable rate and a merely compensatory rate; and in the process of rate making, effective judicial review is very often rendered impossible. The result inherent in the rule itself is arbitrary action on the part of the rate regulatory body, for the rule not only fails to furnish any applicable standard of judgment, but directs consideration of so many elements, that almost any result may be justified."

The conditions under which the reproduction cost theory was developed are pointed out, and his view as to the danger to utilities of its future application, with the possibility of a long period of falling prices.

He holds that in essence there is no difference between the capital charge and operating expenses, depreciation and taxes. Each is a part of current cost of supplying the service, and each should be met from current income.

His confidence in the reform which he urges is great. "The adoption of the amount prudently invested, as the rate base, and the amount of the capital charge as a measure of the rate of return would give definiteness to these two factors involved in rate controversies which are now shifting and treacherous, and which render the proceedings peculiarly burdensome and largely futile. Such measures offer a basis for decision which is certain and stable. The rate base would be ascertained as a fact, not determined as matter of opinion. It would not fluctuate with the market price of labor, or materials, or money. It would not change with hard times or shifting populations. It would not be distorted by the fickle and varying judgments of appraisers, commissions, or courts. It would, when once made in respect to any utility, be fixed, for all time, subject only to increases to represent additions to plant, after allowance for the depreciation included in the annual operating charges. The wild uncertainties of the present method of fixing the rate base under the so-called rule

of Smyth v. Ames would be avoided; and likewise the fluctuations which introduce into the enterprise unnecessary elements of speculation, create useless expense, and impose upon the public a heavy, unnecessary burden."

Mr. Justice Brandeis holds that "What is now termed the prudent investment is, in essence, the same thing as that which the Court has always sought to protect in using the term present value." Many will differ with him in this view. He points out the difference between conditions twenty-five years ago when it was not possible to ascertain with accuracy what it cost in money to establish the utility, or what income had been earned or expended by it, and the present with the accounts of corporations kept according to the standards of and reviewed by public service commissions. He holds that the present situation makes possible the adoption of the prudent investment theory.

He touches upon the many meanings of the word "value" and states "the rule by which the utilities are seeking to measure the return is in essence reproduction cost of the utility, or prudent investment, whichever is the higher," as evidenced by the special report on valuation of public utilities, made by the American Society of Civil Engineers, October 28, 1916.

Mr. Justice Brandeis deserves credit for his clear and fearless expression of opinion. It reflects careful study and a desire to do constructive work, though many of the opinions expressed are directly opposed to those heretofore expressed by the court and followed in a long and fairly consistent line of decisions. It is to be remembered that the opinion was concurred in by but one other member of the Court,—Mr. Justice Holmes.

Mr. Justice Brandeis' view that prudent investment would furnish a better and fairer basis of valuation than the exercise of judgment based upon the results of applying various measures of value and the consideration of all relevant facts, will certainly be seriously challenged. That it may more readily be applied than the multiple standard of valuation dictated by Smyth v. Ames in many, if not most cases, may well be; that it is a workable standard under existing conditions is at least doubtful; that it will make possible the exercise of well-rounded judgment in determining value, and that it will reduce litigation or be more likely to lead to the determination of true value, is not likely.

Mr. Justice Brandeis has, however, done a real service in his clear expression of opinion, the discussion of which hereafter seems certain to clarify understanding.

BLUEFIELD WATER WORKS AND IMPROVEMENT COMPANY CASE—NO. 256

Mr. Justice Butler states "Plaintiff in error is a corporation furnishing water to the City of Bluefield, West Virginia, and its inhabitants. September 27, 1920, the Public Service Commission of the State . . . . made its order prescribing rates. . . . . The company instituted proceedings in the Supreme Court of Appeals to suspend and set aside the order. . . . . A final judgment was entered denying the company relief and dismissing its petition. The case is here on writ of error."

The Supreme Court denied the city's motion to dismiss the writ, on the ground that "there was not drawn in question the validity of a statute or an authority exercised under the State, on the ground of repugnancy to the Federal Constitution."

"The Commission fixed $460,000 as the amount on which the company is entitled to a return. . . . ." It held existing rates insufficient to the extent of $10,000, and authorized increase thereof.

The company claimed that the value of the property was greatly in excess of $460,000. There was submitted to the Commission evidence of value which it summarized substantially as follows:

a. Estimate by company's engineer on basis of reproduction new, less depreciation, at prewar prices.	$624,548.00
b. Estimate by company's engineer on basis of reproduction new, less depreciation, at 1920 prices.....	$1,194,663.00
c. Testimony of company's engineer fixing present fair value for rate making purposes.....	$900,000.00
d. Estimate by commission's engineer on basis of reproduction new, less depreciation, at 1915 prices, plus additions since December 31, 1915 at actual cost, excluding Bluefield Valley Water Works, water rights and going value.....	$397,964.38
e. Report of commission's statistician showing investment cost less depreciation.....	$365,445.13
f. Commission's valuation, as fixed in Case No. 368 ($360,000) plus gross additions to capital since made ($92,520.53).....	$452,520.53

"It was shown that the prices prevailing in 1920 were nearly double those in 1915 and prewar time."

The Commission's analysis was discussed.

Mr. Justice Butler finds "The record clearly shows that the Commission in arriving at its final figure did not accord proper, if any, weight to the greatly enhanced costs of construction in 1920 over those prevailing about 1915, and before the war, as established by uncontradicted evidence, and the company's detailed estimated cost of reproduction new less depreciation at 1920 prices appears to have been wholly disregarded. This was erroneous. . . . . Plaintiff in error is entitled under the due process clause of the Fourteenth Amendment to the independent judgment of the court as to both law and facts. . . . ." "Rates which are not sufficient to yield a reasonable return on the value of the property used at the time it is being used to render the service are unjust, unreasonable and confiscatory, and their enforcement deprives the public utility company of its property in violation of the Fourteenth Amendment. This is so well settled by numerous decisions of this Court that citation of the cases is scarcely necessary." Reference is then made to Smyth v. Ames, 1898; Willcox v. Consolidated Gas Company, 1909; the Minneapolis Rate Cases, 1913; Southwestern Bell Telephone Company case, 1923.

"It is clear that the Court also failed to give proper consideration to the higher cost of construction in 1920 over that in 1915 and before the war, and failed to give weight to cost of reproduction less depreciation on the basis of 1920 prices, or to the testimony of the company's valuation engineer, based on present and past costs of construction, that the property in his opinion, was worth $900,000. The final figure, $460,000, was arrived at substantially on the basis of actual cost less depreciation plus ten per cent for going value and $10,000 for working capital. This resulted in a valuation considerably and materially less than would have been reached by a fair and just consideration of all the facts. The valuation cannot be sustained. Other objections to the valuation need not be considered."

With reference to the rate of return the Court says,—

"A public utility is entitled to such rates as will permit it to earn a return on the value of the property which it employs for the convenience of the public equal to that generally being made at the same time and in the same general part of the country on investments in other business undertakings which are attended by corresponding risks and

uncertainties; but it has no constitutional right to profits such as are realized or anticipated in highly profitable enterprises or speculative ventures. The return should be reasonably sufficient to assure confidence in the financial soundness of the utility and should be adequate, under efficient and economical management to maintain and support its credit and enable it to raise the money necessary for the proper discharge of its public duties. A rate of return may be reasonable at one time and become too high or too low by changes affecting opportunities for investment, the money market and business conditions generally."

It cited the following cases:

Willcox v. Consolidated Gas Company, 1909
Cedar Rapids Gas Co. v. Cedar Rapids, 1912
Des Moines Gas Co. v. Des Moines, 1915
Lincoln Gas Co. v. Lincoln, 1919
The Brush Electric Co. v. Galveston, 1921
City of Minneapolis v. Rand, 1923

and concluded "Under the facts and circumstances indicated by the record, we think that a rate of return of 6 per cent upon the value of the property is substantially too low to constitute just compensation for the use of the property employed to render the service."

The judgment of the Supreme Court of Appeals of West Virginia was reversed.

Mr. Justice Brandeis concurred in the judgment of reversal, for the reasons stated by him in the Southwestern Bell Telephone company case, to wit: "That the order of the state commission prevents the utility from earning a fair return on the amount prudently invested in it."

GEORGIA RAILWAY AND POWER COMPANY DECISION—NO. 298

Mr. Justice Brandeis delivered the opinion of the Court. It is important to note that this decision was rendered by the author of the minority opinion in the Southwestern Bell Telephone Company case and that it was handed down upon the same day, June 11, 1923, as that in the Bluefield Water Works and Improvement Company case discussed above.

"The gas supply of Atlanta is furnished by the Georgia Railway & Power Company. Authority to fix public utility rates is vested by law in the Railroad Commission. On September 20, 1921, the

Commission called upon the Georgia Company to show cause why the then maximum rate, $1.65 per 1000 cubic feet, should not be reduced; and hearings were duly had. The company insisted that under the proposed rate the net income would be less than 3 per cent on what it claimed to be the fair value of the property. The commission concluded that the net income under the proposed rate would be about 8 per cent on the value found by it. This difference in their views as to the percentage of probable return arose mainly from their difference as to the value of the property. The company claimed that it was at least $9,500,000. The Commission found that it was $5,250,000. On December 30, 1921, it ordered that the price of gas be reduced to $1.55.

"The Georgia Company and the Atlanta Gas Light Company, its lessor, then brought, in the federal court for the Northern District of Georgia, this suit to enjoin enforcement of the order, claiming that the rate prescribed is confiscatory. The case was heard upon application for an interlocutory injunction by three judges under Section 266 of the Judicial Code. The court did not approve in all respects the views expressed by the Commission; but it found that 'even were there considerable error in fixing values by the Commission, the rate would not appear to be clearly confiscatory' and that enforcement of the order ought not (to) be enjoined until the reduced rate had been tried. It, therefore, refused the interlocutory injunction; and the case is here on appeal under Section 238 of the Judicial Code."

The decision discusses the case under five captions.

"*First.* The objections mainly urged relate to the rate-base; and one of them is of fundamental importance. The companies assert that the rule to be applied in valuing the physical property of a utility is reproduction cost at the time of the enquiry less depreciation. The 1921 construction costs were about 70 per cent higher than those of 1914, and earlier dates when most of the plant was installed. So much of it as was in existence January 1, 1914, was valued at an amount which was substantially its actual cost or its reproduction cost as of that date. The companies claim that it should have been valued at its replacement cost in November, 1921—the time of the rate enquiry; and that the great increase in construction costs was ignored in determining the rate base."

Mr. Justice Brandeis asserts that "The case is unlike *Missouri ex rel. Southwestern Bell Telephone Co. v. Public Service Commission*, No. 158, decided May 21, 1923," although Mr. Justice McKenna

ridicules this view in his vigorous dissenting opinion. Mr. Justice Brandeis says, "Here the Commission gave careful consideration to the cost of reproduction; but it refused to adopt reproduction cost as the measure of value. It declared that the exercise of a reasonable judgment as to the present 'fair value' required some consideration of reproduction costs as well as of original costs, but that 'present fair value' is not synonymous with 'present replacement cost,' particularly under abnormal conditions."

The lower court gave careful consideration to replacement cost, but held that no rule "required . . . . 'slavish adherence' to cost of reproduction less depreciation.' It discussed the fact that since 1914 large sums had been expended annually upon the plant; that part of this additional construction had been done at prices higher than those which prevailed at the time of the rate hearing; and it concluded that averaging results and remembering that values are . . . . matters of opinion . . . . no constitutional wrong clearly appears." The Supreme Court finds "The refusal of the Commission and of the lower court to hold that for rate making purposes, the physical properties of a utility must be valued at the replacement cost less depreciation was clearly correct," and quotes the Minnesota Rate Cases; Smyth v. Ames; and Willcox v. Consolidated Gas Company. Referring to the action of the lower court Mr. Justice Brandeis says "The opinion of the Court shows that it also made careful examination of the evidence submitted and that it recognized the applicable rules of law. While it differed from the Commission in some matters of detail, it sustained the latter's finding that the value was $5,200,000. The question on which this Court divided in the Southwestern Bell Telephone case, supra, is not involved here."

"*Second.* Two objections to the valuation relate to the exclusion of items from the rate base, namely: the franchise to do business in Atlanta, said to be worth $1,000,000, and so-called losses from operations during recent years, alleged to aggregate $1,000,000. These items were properly excluded. The franchise in question is not a monopoly. It is merely a perpetual permit, ... That past losses are not to be capitalized as property on which the fair return is based was held in Knoxville v. Knoxville Water Co. . . . ; Galveston Electric Co. v. Galveston. . . . . Here this conclusion seems even clearer than it was in those cases. The losses under consideration in the case at bar were obviously not a part of

development cost. They were due to insufficiency of previous rates."

"*Third.* Two further objections to the rate base relate to items of property included in it, which were alleged to have been undervalued . . . . working capital . . . . and going concern. . . . . We are not satisfied that either finding is erroneous."

"*Fourth.* The companies contend that there was error, also, in estimating the amount of the probable net income. One objection relates to the federal corporate income tax (10 per cent). . . . . The Commission treated the tax as a proper operating charge. The court disallowed it; and thus increased its estimate of probable net income. In this the court erred."

"The other objections relate to the amount of the depreciation charge. The companies say the rate should be 2.5 per cent. The Commission and the court allowed only 2 per cent. This question is one of fact, and we are not convinced that it was wrongly decided below."

"*Fifth.* The probable return based on the value and the probable income found by the Commission would be nearly 7.25 per cent. . . . . A return of 7.25 per cent—in addition to this tax exemption—cannot be deemed confiscatory. . . . . In making each of these changes the Commission fixed a rate which it estimated would permit the company to earn a return of about 8 per cent on the fair value of the property. Each change of rate was made upon careful consideration. If there was error, it was error in prophecy or error of judgment in passing upon the evidence. We cannot say that the evidence compelled a conviction that the rate would prove inadequate. . . . . Moreover, the decree is merely interlocutory."

The decision of the lower court was affirmed.

While the language of this decision appears to be in conflict with certain of the principles enunciated in the Southwestern Bell and the Bluefield Water Works decision, it is to be borne in mind that the same citations are made to earlier cases, and that this decision was handed down upon the same day as the Bluefield decision.

A more reasonable interpretation of the decision would seem to be that while the method of arriving at a result adopted by the Commission was not in accord with the principles heretofore laid down by the Supreme Court of the United States, the latter court recog-

nized the fact that the property bought before the war had been valued upon prewar price base, and the portions built during the war period, which were substantial in amount, were appraised at their cost, which was in part at least during a period of extremely high prices—higher than fair for valuation of the entire property,—and it was not satisfied that the figure thus reached was confiscatory and incompatible with an estimate based upon fair prices applied to the entire property.

On the other hand, that the wording of the decision at least, was ambiguous, is indicated by the forceful dissenting opinion of Mr. Justice McKenna, handed down upon the same day (June 11, 1923) as the decision.

Georgia Railway and Power Co.—Minority Opinion of Mr. Justice McKenna

He says "I am constrained to dissent on the authority of Missouri ex rel. Southwestern Bell Telephone Company v. Public Service Commission of Missouri, et al, decided May 21, 1923, and Bluefield Water Works and Improvement Company v. Public Service Commission of West Virginia, decided today.

"These two cases follow other cases which they cited, including that of Smyth v. Ames, decided a quarter of a century ago, declaring the rule of regulation to be, that in order to fix a rate for the use of property devoted to the public service, the property must be estimated 'at the time it is being used for the public.'" And again, "'that the value of the property is to be determined as of the time when the inquiry is made regarding rates.'"

"The Commission in the present case conceded the rule, and violated it, and upon a unique justification. It said 'The human race is only recovering from an experience the like of which the world never before endured—a world war—a world upheaval—an economic cataclysm. There are no stable measures of value to-day.' Upon this the Commission departed from the values which then prevailed, and from those that the rule of law prescribed, that is, the values prevailing at the time the property was being used for the public, and reverted to the values which obtained January 1, 1914,—values that had not existed for over seven years, and no prophecy could say when, if ever, they would exist again.

"To separate the Company from the conditions which existed at the time of regulation was arbitrary and condemned it, the Company,

to accept an inadequate return upon the value of its property, not only for the then time, but for an indefinite future time. Similar action was condemned in the Telephone case—no 'economic cataclysm' repelling. Similar action was condemned in the Bluefield case—no 'economic cataclysm' repelling.[2] May I ask what had become of the 'cataclysm?' Had it settled in Georgia in conscious indulgence to life and business in other parts of the country from its bewildering influence?

"The contrariety of decision cannot be reconciled. To anticipate a possible criticism, however, I should say a distinction is attempted to be made between this case and the Telephone case, a distinction, I think, not sustained by the record. It is said that the present case is unlike the Telephone case, in that 'here the Commission gave careful consideration to the cost of reproduction; but it refused to adopt reproduction cost as the measure of value.' The omission was the Commission's error—it was in disregard of the rule of the cases, disregard of the value of the utility at the time of its regulation—the time it was being used by the public. And such value was available. The problem was direct and simple—with no baffling element in it."

"The cost of the materials and of their fabrication was as much a measure of the value of the utility when reproduced as the cost of materials and their fabrication were a measure of the value of the utility when it was produced—a measure of value of reproduction and production."

"No attempt, however, is made to justify this case and the Bluefield case. It seems to be taken for granted that they can coexist in the books in harmonious association. Can they?"

"The Bluefield case decides . . . . that the Commission . . . . did not accord proper, if any, weight to the greatly enhanced costs of construction in 1920 over those prevailing about 1915 and before the war, as established by uncontradicted evidence . . . . this and the Bluefield case, are identical in errors. . . . . the Commissions did exactly the same thing, and yet the action of one is affirmed, and the action of the other reversed. This contrariety of decision I cannot reconcile. There should be reversal of both or the affirmance of both if their identities are to be observed.

[2] "The lower Federal Courts have not felt the bewildering effect—impotent effect I might say—that the Commission discovered in the post-war conditions. . . . . And a State Court has been equally free from confusion."

I, therefore, must dissent from one or the other of the cases, and as the Bluefield case has the support of the Telephone case, I dissent from the present case, there being a majority against it, and those cases, besides expressing my view of the law."

"It may be said that if I get rid of the Commission's action, I must take account of the District Court's judgment of it upon an independent consideration of the record. I realize that the challenge has serious strength, but as the Court's opinion is very long, I can only meet the challenge by what I consider the error of the opinion. The Court disregarded, as the Commission did, the rule of law that the value of the Company's utility should be at the time it was being regulated, that is, at the time it was being used. The Court, however, did not entirely agree with the Commission. It said 'in ascertaining the present values of physical properties, though correct rules were announced by the Commission, we do not think they were exactly followed.'"

FIRE PROTECTION REQUIREMENTS IN DISTRIBUTION SYSTEM DESIGN

By V. Bernard Siems[1] and D. Benton Biser[2]

The maximum discharge that may be required of a water distribution system is the quantity to be delivered for the purpose of fighting fires, and the proper provision for such a draught is the principle obligation of the distribution system design.

The quantity needed for fire protection, as compared to the total distribution capacity, is related in a general way to the population, the ratio decreasing as the population increases. A small town must devote a relatively greater proportion of its pipe line capacity to fire protection than a large city, and obviously, in the residential section of a city that proportion must be greater than in a commercial or industrial section. Likewise, the per cent of cost of the distribution system required for fire protection is inversely proportional to the population.

COST OF FIRE PROTECTION

This proportion, according to the judgment of Metcalf, Kuichling and Hawley (American Water Works Association Proceedings, 1911) is represented by the equation $Y = \frac{147}{X^{0.31}} - 12.1$ in which Y equals per cent of total cost, X equals population in thousands. By substitution in the equation this curve has been projected to a population equal to that of Baltimore (fig. 1). This is of comparative value only, however, as indicating the general trend and is unreliable when applied to the individual plant where there is any substantial deviation from normal conditions.

Although the per capita per day consumption for fire protection is too low to be considered in the total yearly consumption of a community, yet the value of this service to the community cannot

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be measured too highly in the saving in fire insurance premiums and in the economic loss resulting from fires. Although the quantity used for this purpose is small, when needed it must be delivered quickly and might tax the capacity of a system not designed to provide for this exigency.

STUDIES OF DISTRIBUTION SYSTEM PERFORMANCES

A distribution system, no matter how carefully designed to satisfy the requirements of a community, may in the course of time prove inadequate because, after all, it is an almost unalterable structure.

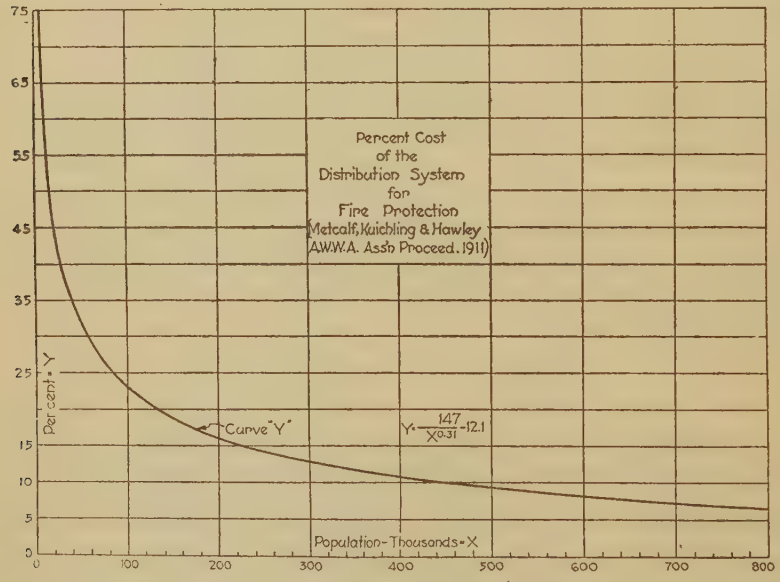

FIG. 1

The future needs for which it was constructed were assumed at the time, unless the development of the community for which it was designed was directed in an orderly manner by a systematic scheme of zoning. Let the character of the development change and the existing gridiron becomes inadequate, although this inadequacy may not be manifest, for the gridiron may yet be delivering sufficient water for consumption and the pressure may still remain unchanged by customary draughts upon the system. Casually, conditions are as good as at the time the system was designed, but the limit of

efficiency, beyond which the inadequacy of the system will become evident, may already have been reached.

In order to ascertain the true condition of an existing distribution system two studies are necessary—pressure surveys and investigations of the actual capacity of the system throughout its extent. An understanding of these properties not only indicates the manner by which the performance of the system might be improved, but also provides the fundamentals for new designs.

THE PRESSURE SURVEY

By the pressure survey there should be secured records of pressures during twenty-four hour periods. Information of any value in the study may be obtained only from such records, which show the maximum and minimum pressures during the period, the oscillation due to the nature of the supply source, and the possibility of water hammer in a gridiron that is insufficient to meet the required draughts, indicating the need for larger secondary mains or additional feeder main capacity; or, on the other hand, they may confirm the efficiency of the gridiron for its normal consumption draughts. By a comparison of the observed pressures with the theoretical pressures a fair idea of the consumption may be had. The record of the averages of the twenty-four-hour pressures may be made easily accessible by means of iso-baric lines upon a map of the town.

But a pressure survey is of value only as an indicator of conditions, for static pressures, even though they be theoretically ideal, may be misleading. A gridiron of small mains or even a large but long unsupported feeder main may consume in friction a high static pressure, and consequently any increase in pressure not brought about by larger mains, but principally only by extending the zone of a higher service to include sections of a lower service, or by increasing the static head in some such way, is not of lasting benefit, especially in a town whose consumption may be readily increasing.

FLOW TESTS ON FIRE HYDRANTS

Therefore, closely allied with the study of the pressures maintained in a water distribution system should be investigations of the actual capacity of the system throughout its extent. For such investigation as in the research that is being conducted in Baltimore for the improvement of the present system and the standardization of design,

use is made of a particular method which consists in making flow tests on fire hydrants. This is undoubtedly the most practical, economical, and instructive method of studying the efficiency of a distribution system.

The test is first carefully planned in the office. The boundary of the district to be investigated is determined. Due consideration is given to the normal consumption of the territory, the character of the feeder mains, the distance from the source of supply, the difference in elevation, age of pipes, etc., so as to calculate the size of an equivalent main from the source of supply to the point of test and the approximate quantity which theoretically should be discharged. In other words, the delivering capacity of the system at a focal point where the influence of the test upon the pressure in the system is to be observed is ascertained. The sizes of the water mains composing the gridiron are also considered and the number of fire hydrants to be used are selected.

With such preparations, the field operations are quickly, though accurately, made. Readings of the static pressure are taken at a central hydrant. The group of selected hydrants are then opened and, after the flow as indicated on the test gauge at the central hydrant has become stabilized, their individual discharges are measured simultaneously with a pitot tube attached to a calibrated gauge, which registers the velocity pressure of the issuing stream, care being taken to detect areas of no flow which may occur in weak streams or certain types of hydrants. During this operation the pressure at the central hydrant has dropped due to the heavy draught through the gridiron. Readings of this residual pressure are taken and the group of open hydrants closed. The registered velocity pressures converted into the corresponding quantities of water, correction being made for the type, size of outlet, the nature of the stream, etc., may then be compared with the theoretical quantities calculated.

Flow tests are of particular value for the various kinds of information they provide, which may be (*a*) the condition of the water mains with respect to obstructions such as closed valves, acute bends, etc. A study of the volume from each hydrant enables the engineer to locate the presence of such obstructions. (*b*) The discharge capacity of the existing mains and the efficiency of the gridiron. (*c*) The proper sizes of proposed mains. (*d*) The probable need of supporting mains or additional gridironing. (*e*) The reserve capacity of the system to meet such exigencies as serious fires, broken feeder

mains, etc. (*f*) The effect upon the gridiron of a definitely measured draught which serves as data from which may be calculated the effect of any consumption.

Flow tests on fire hydrants are necessary in studying fire protection probabilities, since the ability of the system to deliver the maximum quantity demanded by the test is comparable to the provision that should be made to meet the requirements of adequate fire protection.

FACTORS OF DISTRIBUTION EFFICIENCY

Pressure

The efficiency of the system for extinguishing fires depends upon the quantity of water that can be discharged at a certain pressure from fire hydrants a reasonable distance from the fire, which quantity is limited by the capacity of the source of supply, the static pressure, and the size and length of the water mains. Moreover, the efficient gridiron, besides delivering the necessary fire flow, should be capable at the same time of maintaining a residual pressure fairly sufficient for the needs of the ordinary consumption in the particular section supplied by it. This residual pressure, therefore, which is universally taken as 20 pounds is a fundamental consideration upon which the design of the gridiron must be based, and the size of the water mains to be used must be relative to the static pressures in the water distribution system.

Ordinarily, enough streams must be available with sufficient pressure to reach the roofs of buildings up to four stories in height and also to reach the seat of the fire through the flames, which is only possible with large and powerful streams. Small streams are easily vaporized by the heat of a large fire and hence are ineffective. Cities where fire engine pumps respond to each fire need not depend upon exceedingly high static pressures. With a properly proportioned distribution system and effective methods of fire fighting, hydrant pressures of 30 or 40 pounds are as good as those of 60 or 80 pounds. The additional pressure does not benefit the pumper, a fire engine being able to pump as long as there is pressure enough at the hydrant to deliver water to the pump. Very high pressures (100 to 200 pounds per square inch) tend to cause leaks and increase underground waste. It is far more important to have main capacity than to have high pressure.

However, a gridiron should not be dependent upon pumps to ensure a discharge sufficient for fire flows, but should have provided a static pressure great enough to produce effective fire streams unaided by pumps. Therefore, in a gridiron designed to deliver the proper quantity of water, 60 pounds pressure is desirable and should be the aim of the water works engineer to furnish in the distribution of water service.

Required fire flow

The next factor of distribution efficiency to be considered is that which limits the relation existing between the static pressure in the system and the size of the water main, that is, the probable fire flow required. This flow may be estimated for each type of development according to the method recently outlined by the National Board of Fire Underwriters, which developed as the result of cooperative studies conducted by J. H. Howland of the National Board of Fire Underwriters and the Baltimore City Water Department in the Highlandtown-Canton district of Baltimore. In this method the character of buildings, their undivided area, their height, combustibility, together with the fire department facilities are considered. A consideration of the factors which govern the adequacy of the water mains controls, therefore, any comprehensive study of a distribution system from a fire protection viewpoint.

Calculation of required fire flow

It was first believed that the required fire flows for a community were limited by its population and several formulae were developed. Shedd proposed an equation in which the number of fire streams, taken to be 250 gallons per minute each, was equated to $0.005\sqrt{\text{population}}$. Kuichling developed one in which the number of fire streams $= 2.8\sqrt{X}$, X being the number of thousands of population. The National Board of Fire Underwriters adopted a formula, which, in its finally revised form, became discharge in gallons per minute $= 1020\sqrt{X}(1-0.01\sqrt{X})$, X being population in thousands.

This formula modified somewhat by a consideration of structural conditions and features affecting the fire hazards is still quite universally used, but experimental data from the field confirm the growing belief that the flows required in a small town may not be relatively proportional to those in a large town; the entire population

of the small town might be engaged in one industrial enterprise and consequently the fire flow may be incomparable to that for the larger towns. Population should not be the single limiting factor. A new method of estimating required fire flows was evolved in which many variable factors were introduced and which was represented by the equation, $Q=(X+H)\ A+1000+(200E)$, for areas exceeding 2500 square feet, to be applied for fire areas up to 10,000 square feet, and $Q = (X+H)\ A+5000+(200E)$, for fire areas over 10,000 square feet. In these formulae A = area of undivided fire area of individual buildings or closely grouped buildings; H = factor depending on height and area of buildings, which for an area less than 10,000 square feet is

0.25 for 1-story
0.28 for 2-story
0.30 for 3-story
0.31 for 4-story
0.32 for 5-story
0.33 for 6-story and over

and for areas over 10,000 square feet H =

0.05 for 1-story
0.08 for 2-story
0.10 for 3-story
0.11 for 4-story
0.12 for 5-story
0.13 for 6-story and over

E = the number of engine or hose companies in excess of fire in service in the city, not to exceed fifteen in any case; X = the factor for combustibility of contents; 0.01 for low, 0.04 for average and 0.08 for high combustibility.

But an ideal equation should be applicable to all cases. This method, therefore, is undergoing a gradual revision and is not yet in its final stage, but is being critically applied to field conditions by the engineers of the National Board of Fire Underwriters. In this city much experimental work is being conducted by the Distribution Division of the Water Department to determine the value of the formula as an equation to be universally accepted.

It may be readily understood that the flow required to combat a fire depends in a great measure upon the height, fire area, and combustibility of a structure. The adjudgment of combustibility need not be hypercritical, for its varying degrees, as the case may

be, above or below an average, adds to or subtracts from the total quantity required.

The structural height of fire hazards may be limited in all considerations to six stories. Higher buildings are as a rule of modern fire proof construction and provided with house pumps; and moreover, a fire on the higher floors is reducible to or merely considered, for all purposes, as a fire in a structure of a height equivalent to the number of floors involved. This is brought out in figure 2, where it is seen that the increasing height tends to decrease the quantities, and that proportionally the greatest quantities are needed below the third story.

The most important factor is the fire area, that is, the area undivided by a fire wall, through which a fire may spread unhampered. Thus the brick walls dividing a continuous row of buildings do not constitute fire walls unless they are continued above the roofs by so-called parapet walls, for, without this, a fire, though obstructed within the building, would be unhindered from spreading under the roof to adjacent buildings.

The three factors noted above are not sufficient of themselves to determine the required flow. The experience of the National Board of Fire Underwriters indicates that there are other items to be introduced, one of which is the maximum fire engine pump capacity considered—which in any case should not exceed 10,000 gallons per minute, the equivalent of 40 good fire streams or thirteen 750 gallon-per-minute fire pumps. One-third of the difference between the maximum fire pump capacity considered for a fire area of any size, and the average fire engine pump capacity provided must be added to the fire flow required as determined by the height, fire area, and combustibility factors. This difference between the maximum and average fire pump capacities represents the approximate quantity of water that is required to provide for the quantity lost through wastage in hose couplings, broken hose, pump slippage, main and hydrant obstructions, etc. It is evident that the entire quantity of water used at a fire does not fall upon it.

Research to determine a correction factor ("Baltimore equation")

Aside from this modification it has been our contention that this allowance for the extra quantity of water needed at a fire, which is so closely related to the number of fire streams and hence directly related to the fire area considered, should be further defined. The

need for a more complete definition of the factor, upon which we have been working, has also been expressed by the National Board of Fire Underwriters, who have been applying their formula to field conditions. It is our belief that, although the fire area proper should remain that enclosed by fire walls, yet adjacent buildings, if there are any, are exposed and not a small quantity of water must be provided to protect these exposed areas.

Applications of the formula emphasize the importance of this exposure factor, which is a variable defining the fire area. Unless this definition is made, an isolated structure, surrounded by its grounds or bounded by wide streets, permitting of easy access and distribution of fire fighting forces, would require, according to the present formula for determining fire flow, the same quantity of water for protection as a structure of the same height and area adjoined by other hazards in a congested section.

It is reasonable to assume that this quantity would be negligible for very small fires, but would increase greatly as the extent and seriousness of the fire increases. In reality the records of past fires and the judgment and experience of the Chief of the Fire Department, City of Baltimore, indicate that this quantity increases as the square of the probable required flow. The compilation of all the available data on the excess quantity necessary to protect structures menaced by fires in an adjacent building produces a parabolic curve the equation for which is found to be: excess quantity in gallons per minute, representing this exposure factor, equals the square of the probable fire flow, in gallons per minute, as calculated by the National Board of Fire Underwriters' method, divided by 50,000 or symbolically expressed $X = \frac{Y^2}{50000}$.

This correction need not be applied to the quantity calculated for fire areas exposing other buildings from one side only, but is only to be added when the exposure to fire is on two or more sides and substracted whenever there is no exposure. It has been our endeavor to revise the formula of the National Board of Fire Underwriters to conform to all conditions and to develop a method for determining quantities for fire protection applicable to great and small structures in large and small towns alike.

Application of revised equation for fire flows

Diagrams 1, 2, 3 and 4 in figures 2, 3 and 4 illustrate the successive steps in calculating therequired fire flow.

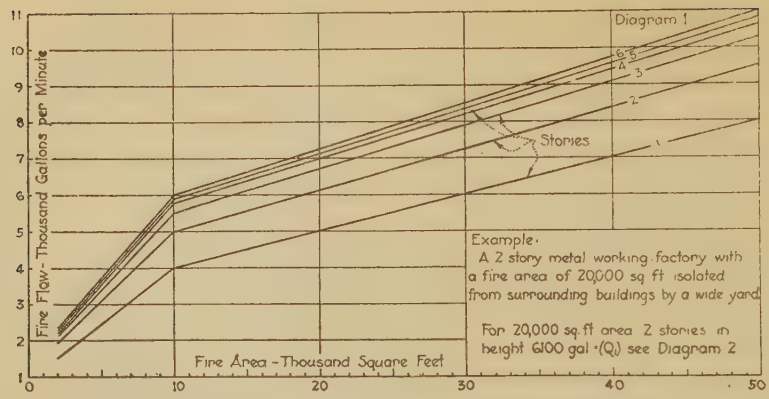
Diagram 1
Fire Flow - Thousand Gallons per Minute
Stories
Example:
A 2 story metal working factory with a fire area of 20,000 sq ft isolated from surrounding buildings by a wide yard
For 20,000 sq. ft area 2 stories in height 6100 gal. (Q1) see Diagram 2
Fire Area - Thousand Square Feet

FIG. 2. THE NATIONAL BOARD OF FIRE UNDERWRITERS TENTATIVE DIAGRAMS SHOWING THE FIRE FLOWS REQUIRED FOR FIRE AREAS OF VARYING HEIGHTS (Q_1)

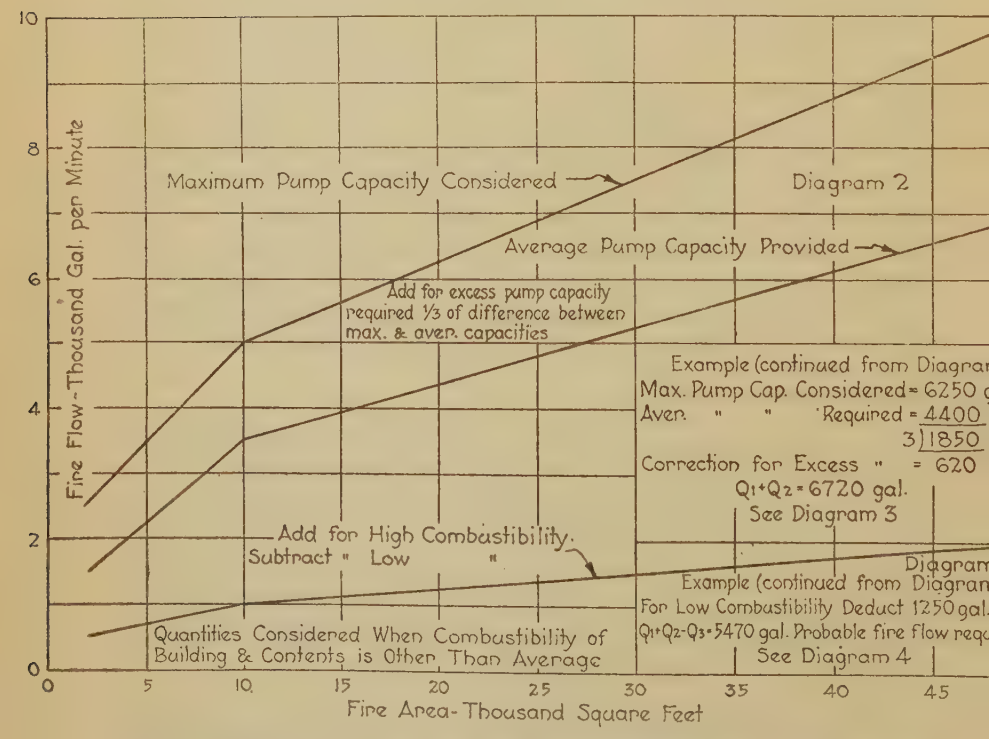
Fire Flow - Thousand Gal. per Minute
Maximum Pump Capacity Considered
Diagram 2
Average Pump Capacity Provided
Add for excess pump capacity required 1/3 of difference between max. & aver. capacities
Example (continued from Diagram
Max. Pump Cap. Considered = 6250
Aver. " " Required = 4400
3)1850
Correction for Excess " = 620
Q1+Q2 = 6720 gal.
See Diagram 3
Add for High Combustibility.
Subtract " Low "
Diagram
Example (continued from Diagram
For Low Combustibility Deduct 1250 gal.
Q1+Q2-Q3 = 5470 gal. Probable fire flow req
See Diagram 4
Quantities Considered When Combustibility of Building & Contents is Other Than Average
Fire Area - Thousand Square Feet

FIG. 3. THE NATIONAL BOARD OF FIRE UNDERWRITERS TENTATIVE DIAGRAMS SHOWING FIRE ENGINE PUMP CAPACITY (Q_2) AND COMBUSTIBILITY (Q_3)

Diagram 1, figure 2 represents a judgment, based upon studies conducted in the Highlandtown-Canton District mentioned above,

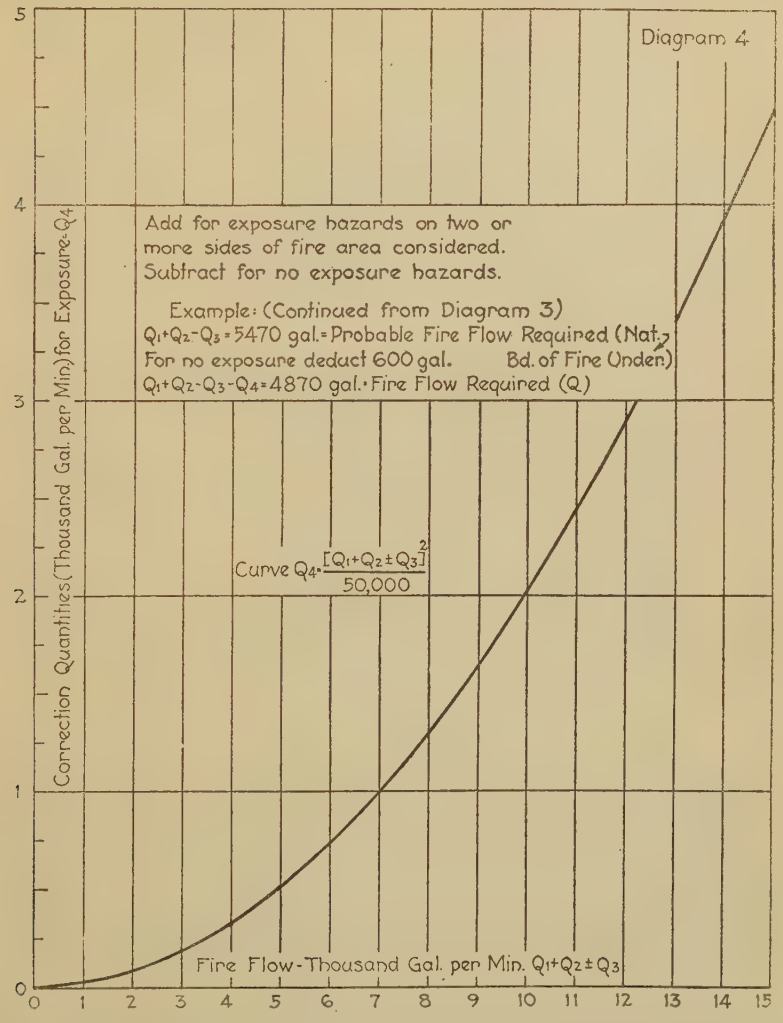
Diagram 4
Add for exposure hazards on two or more sides of fire area considered.
Subtract for no exposure hazards.
Example: (Continued from Diagram 3)
$Q_1+Q_2-Q_3$ = 5470 gal. = Probable Fire Flow Required (Nat. Bd. of Fire Unders.)
For no exposure deduct 600 gal.
$Q_1+Q_2-Q_3-Q_4$ = 4870 gal. = Fire Flow Required (Q)
Curve $Q_4 = \frac{[Q_1+Q_2 \pm Q_3]^2}{50{,}000}$
Correction Quantities (Thousand Gal. per Min.) for Exposure-Q_4
Fire Flow-Thousand Gal. per Min. $Q_1+Q_2 \pm Q_3$
0 1 2 3 4 5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

FIG. 4. EXPOSURE FACTOR (Q_4) FOR CORRECTION OF PROBABLE REQUIRED FIRE FLOW, "BALTIMORE EQUATION"

of the fire flow required for buildings or groups of buildings so situated as to constitute essentially one fire area, of heights from one

to six stories. For the better understanding of the application of the diagrams an example is given. The indicated quantity on diagram 1 for the building, which is a metal working factory covering 20,000 square feet and two stories in height, is 6100 gallons per minute, which may be designated by (Q_1) in the equation $Q = Q_1 + Q_2 \pm Q_3 \pm Q_4$.

The next factor (Q_2) represented by diagram 2, figure 3 is the excess fire engine pump capacity that should be provided. As pointed out, this quantity is obtained by allowing one-third the difference between the maximum pump capacity considered and the average pump capacity provided, which, for the building considered, is 620 gallons per minute; which added to Q_1 brings the total required flow to 6720 gallons per minute.

The combustibility factor (Q_3), shown in diagram 3, figure 3, which in this case is equivalent to 1250 gallons per minute to be deducted from the previous total, since the building is a metal working factory and hence of low combustibility. By this operation the probable fire flow required becomes 5470 gallons per minute.

To this quantity is now applied the "Baltimore equation," the correction for exposure, (Q_4), (fig. 4). From the diagram it is found that the correction quantity corresponding to the flow of 5470 gallons per minute is 600 gallons per minute. Since the building is isolated, this figure must be deducted from the total flow, making the total corrected fire flow required 4870 gallons per minute.

ELEMENTS OF DESIGN

Estimation of fire flows based upon future development of a community

In estimating the probable required fire flows in this city, we consider the future development of each section according to the regulations outlined by the Zoning Commission, and from analysis of the actual trend by field inspections. Such practice should be universal. In order to design a water distribution system intelligently, the character of the future development of the community and the location and widths of proposed traffic arteries must be known. Many times in communities where a system of city planning was not followed, small mains have been laid into new territories on the theory that the demand would be slight, only to be replaced by larger mains when the territory became more closely built or its character changed. Where a system of city planning is followed,

the future consumption in a newly developed territory may be anticipated and although the gridiron and even the supporting

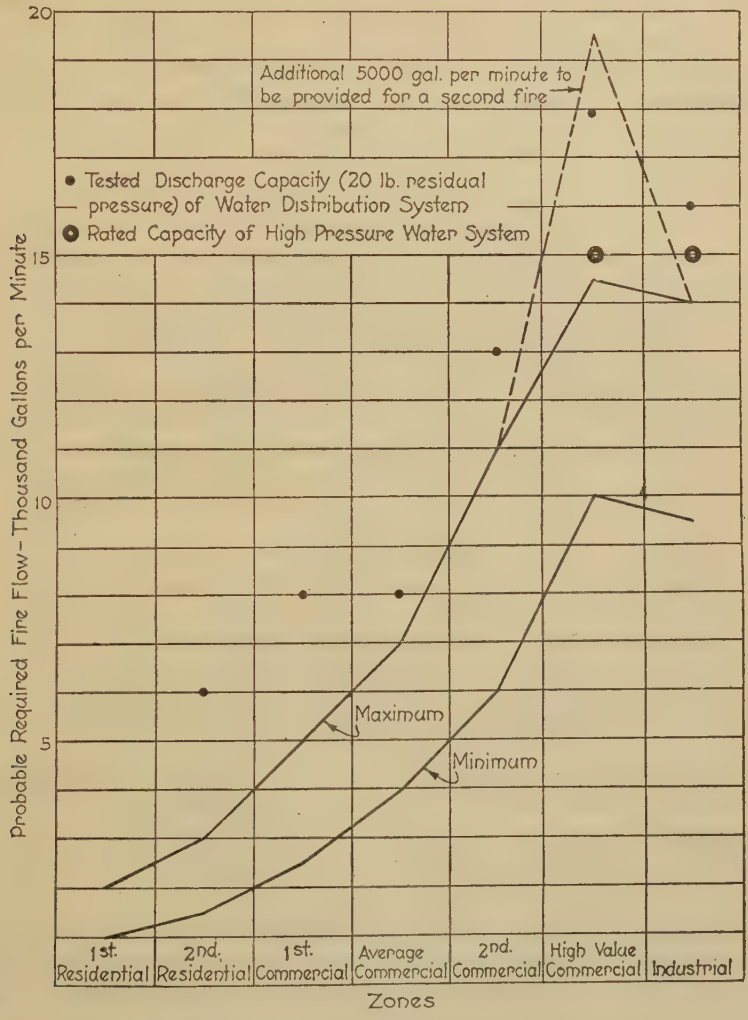

FIG. 5. PROBABLE FIRE FLOWS REQUIRED FOR SERIOUS FIRES IN THE VARIOUS DEVELOPMENT ZONES OF BALTIMORE CITY, 1923

system of lateral feeder mains may not be complete for some time, yet a determination of the size of the feeder main extension to be economically installed may be made in advance.

Figure 5 shows the probable limits of the fire flows required in the various development zones in a city like Baltimore. It is seen that the maximum for the first residential zone is 2000 gallons per minute, for the second residential zone 3000, for the average commercial zone 7000, and for the high value commercial and mercantile zones 14,500 gallons per minute, with an additional 5000 gallons per minute to provide for a second fire in this hazardous district.

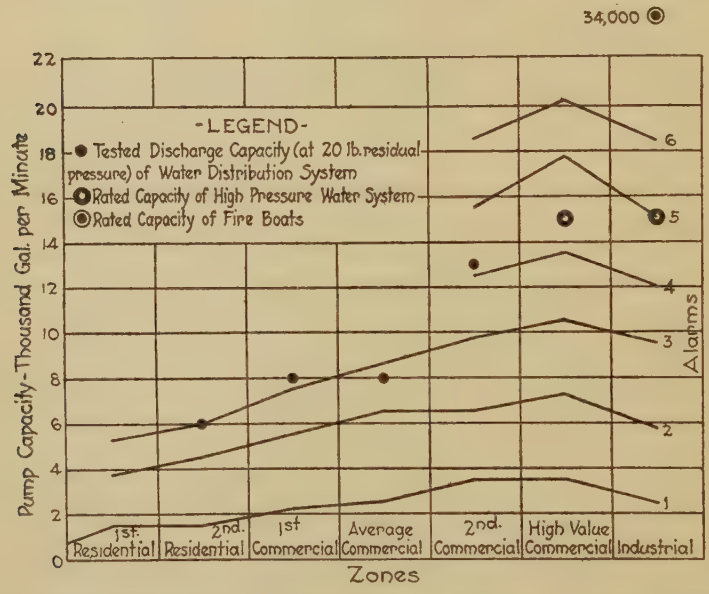

FIG. 6. FIRE ENGINE PUMP CAPACITY RESPONDING TO ALARMS IN THE VARIOUS DEVELOPMENT ZONES OF BALTIMORE CITY, 1923

Note: This diagram is a comparison of the fire apparatus requirements and the capacity of the distribution system in Baltimore.

While this diagram applies specifically to Baltimore, we believe it is suitable for general application, without alteration, to cities of Baltimore's type, and to smaller towns or villages, through a comparison with the similar zones of development.

To facilitate the comparison of structural conditions in a small town with those indicated on the diagram, the designated zones may be defined as follows: *First residential*—a purely residential development without stores, the dwellings being individual and surrounded by yards. There are no large apartment houses in this zone. *Second*

residential—this development is more congested. Dwellings may be in block construction with occasional community stores. Structures in this zone are not generally separated by yards. *First commercial*—although this development is partly residential in character, the number of small stores is greatly increased. It represents a transitional stage in the development of a residential community to one commercial in character. Here are found the typical store-front dwellings. *Average commercial*—this zone embraces the smaller commercial and minor mercantile enterprises. There are very few dwellings, although some structures may have apartments on the upper floors. *Second commercial*—this zone is a congested, purely commercial section, buildings are large and high. *High value commercial*—this zone represents the limit of the commercial development. Here are the largest structures to be found in the town, the greatest fire hazards, the most congested development, the most valuable property. *Industrial*—the name of this zone is descriptive of its character. Here are grouped more or less closely the large industrial plants of a town.

Water main capacity

Knowing the delivery capacity desired, as calculated by the method of required fire flow, and the static pressure provided, by considering the friction losses caused by the desired flow, the proper size of water mains and their permissible length may be ascertained. In the design, however, ample margin should be provided for the future growth, the character of development, and the increased consumption caused by the growth of the district to be supplied, as well as the relative effect of aging upon the capacity of the water mains. Incidentally the increase in velocity, resulting from a greater consumption, especially in small mains, may approximate their critical velocity and hence cause that main to have reached the limit of its serviceability while yet comparatively new.

Mains smaller than 6 inches in diameter should never be considered, except under very special conditions, in designing a gridiron. A very short length of 4-inch pipe is inadequate for delivering two good fire streams of 500 gallons per minute and even then the friction loss caused by such a discharge would necessitate a very high static pressure, and the velocity produced in the pipe by the discharge would be four times the critical velocity for a pipe of that size.

Source of supply

Another important factor of the efficiency of the system is the capacity of the source of supply which should provide at least for a maximum fire draught of ten hours duration at a sustained pressure during the peak period of domestic consumption and during the dry season.

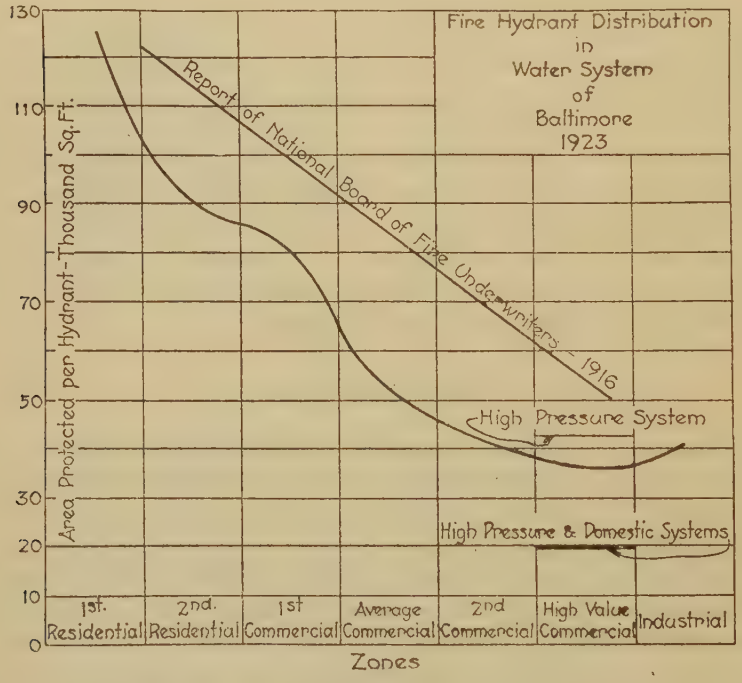

FIG. 7

Delivery capacity and fire hydrant distribution

With the source of supply, the pressure, and the gridiron capacity provided for, the delivery of that capacity is dependent upon the number of fire hydrants available, and inversely, the number of fire hydrants should be determined by the desired discharge. Where there are fire engines in service, the average area protected by a single hydrant, which depends upon the number of fire streams made necessary by the requirements of fire protection for that district, may be somewhat greater than where no engines are available; and as the

required fire flow is increased the area per hydrant should be decreased.

The area of a city block, providing the streets are not uncommonly narrow, constitutes the natural fire area unit and affects the spacing of fire hydrants. The probable required fire flow for a block that is congested and consists of two and three story brick dwellings in block construction interspersed with stores would be about 4000 or 5000 gallons per minute. According to the schedule of the National Board of Fire Underwriters, this flow would necessitate a hydrant distribution sufficient to limit the protected area per hydrant to 85,000 or 90,000 square feet or one to two hydrants for each city block. A less congested block of dwellings, in which there are no large apartment houses, a development as might be found in the outlying districts of the residential parts of a city, would require a fire flow of not more than 2000 gallons per minute and a corresponding average area per hydrant of 110,000 or 120,000 square feet or one hydrant for each city block. It is not our practice to include highways, whose width exceeds 80 feet, in determining the hydrant distribution, as such a width serves as a barrier against the spread of fire, and to include it in the area protected by the hydrant seems unjust.

On gridirons of secondary mains, hydrants should be placed only at highway intersections in order to ensure accessibility to them and a well supported flow from the converging mains in the cross highways.

Fire hydrants should be systematically allocated, with the following precepts in mind:

1. They should be equidistant from each other.

2. They should be placed at the same relative corner of the highway intersection to make for uniformity and to facilitate their discovery by the fire department; in order to provide for this, there should be either parallel mains, one on each side of the street, or the single main should be centrally placed; as the hydrant branch should always be as short as possible to reduce friction losses, this uniformity of distribution would otherwise be impossible.

3. There should be at least one hydrant within the boundaries of each city block in order to provide in as many cases as possible against the necessity of crossing car tracks with hose lines.

Two schemes for the systematic distribution of fire hydrants are illustrated in figure 8.

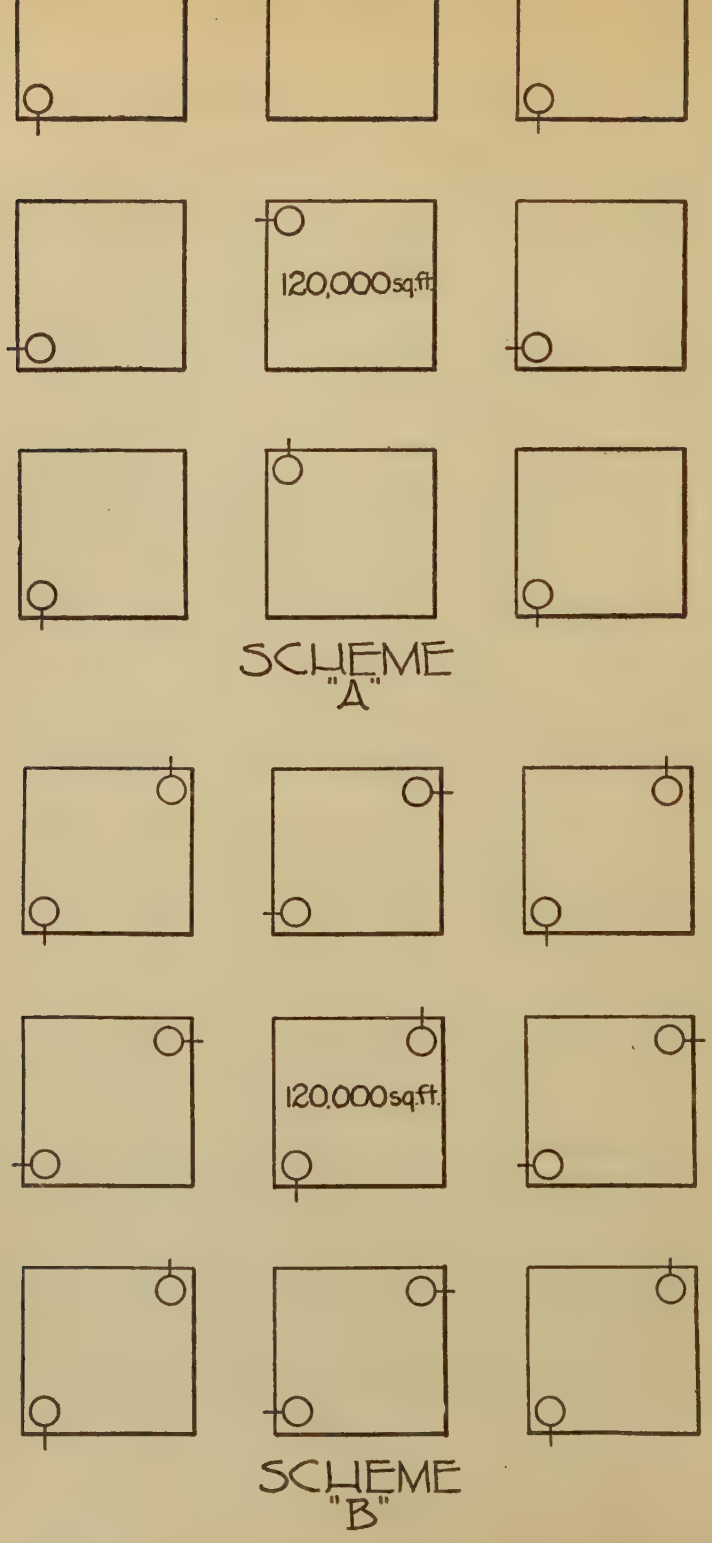

Fig. 8. Schemes for a Systematic Distribution of Fire Hydrants

Scheme "A" is the proposed distribution for one hydrant per city block of 120,000 square feet. It will be seen that there is a hydrant at each street intersection, there are two hydrants available on each face of the block, whereas hydrant distribution requires only one per 120,000 square feet, yet by this arrangement four hydrants are in reality available within a radius of about 200 feet about each block.

Scheme "B" is that for two hydrants per city block, or a distribution equivalent to one hydrant per 60,000 square feet. By this arrangement two hydrants are placed at each intersection, making four hydrants available on each face of the block, and eight hydrants available within a radius of about 200 feet about the block.

Designing for fire protection

In the determination of the capacity for which the gridiron is to be designed, the domestic consumption may be neglected in residential sections, the fire flow being taken as the total discharge through the pipe. Indeed the same principle is indicated in the commercial and industrial sections, as it has been found that the required fire flow greatly exceeds the consumption demand. Yet the consumption in such developments, is considerable, and as there is usually a certain period during the day when it reaches a peak far above the average draught, some allowance for the domestic consumption in the determination of the necessary pipe capacities of the supply mains seems to be necessary. Investigations are now in progress in Baltimore to determine, if possible, a relationship between the pipe capacities made necessary only by the required fire flows and those for the fire flows combined with the domestic draught.

In the determination of the pipe size for a new system, analytical methods are employed. The available static pressure, the required discharge and the hydrant distribution made necessary by this discharge are known. The size of the supply mains to the new territory may be judged by the quantity to be furnished and a permissible loss in head, considering the available static pressure, to the edge of territory. The summation of the friction loss in the feeder mains outside the section, the hydrants and hydrant branches, the number of which is determined by the required fire flow, and the allowance of 20 pounds residual pressure in the system, deducted from the static head, gives the total remaining head available for friction loss in the gridirion, upon which to base the size of the secondary mains.

In the calculations a fair allowance for aging, tuberculation, etc., of the pipes may be made by taking $C = 100$ in the Hazen and Williams' tables.

For example: assume two principal highways extending from a town, separated by a distance of 3000 feet, and from both of which a residential development is gradually expanding to eventually form a completely built-up area between them. Let it be assumed that the development has reached a point about 700 feet, or about two blocks, from the highway, and that it is desired to extend a water main to this point. Let the nature of the development be such that, with a hydrant distribution as recommended, a discharge of 500 gallons per minute is required from each hydrant. Let the loss in the hydrant and hydrant branch, flowing 500 gallons per minute, be 4 pounds, and the loss in the outside system up to the point from which the new main will be taken, be 4 pounds. The sum of these losses, added to the residual pressure of 20 pounds, which is the desired pressure to be maintained in the system during the discharge, is 28 pounds. Let the difference in elevation between the point considered and the source of supply be such that the theoretical static pressure is 35 pounds. Then this pressure, less the 28 pounds above, leaves 7 pounds, which is applicable for friction losses in the new water main. By reference to the Hazen and Williams' tables, it is found that 500 gallons per minute is available with this loss through 770 feet of 6-inch main.

But provision must also be made for the future development. Assume that the development has passed the point considered above and, in this process, has become more congested and requires a greater quantity of water for adequate fire protection. If the 6-inch main were extended to join the supply main in the other avenue, 3000 feet distant (which in this case it is assumed is in every way equal to the supply main first mentioned), so that the new main would receive equal supplies from both ends, then by the same method of calculation, it is found that where the 500 gallons per minute was before available, there is now an available discharge of 783 gallons per minute. At the weakest point in the design, midway between the two avenues, there is available a discharge of 704 gallons per minute. Therefore, it may be assumed that with these conditions a 6-inch main will not only provide for the present, but, as the first step in a progressive gridiron design, will be ample for future requirements.

Fire protection requirements in European design

There does not seem to be much importance given to fire protection in European distribution system design. One German authority allows 4 or 5 liters per second for fire protection in addition to the quantity estimated for the domestic consumption. Hydrant branches are installed at distances of 50 to 120 meters, although hydrants are first installed only on the alternate branches. The sizes of the mains are determined from the estimated per capita consumption per linear meter of improved highway, and mains as small as 100 millimeters in diameter are permitted in the design.

CONCLUSIONS

Fire protection is a paramount obligation upon a water works. To ignore this obligation is calamitous. By the flow test we may judge the ability of a water system to furnish the territory it supplies with adequate fire protection. By applying the principles upon which such tests are based we may be guided in designing new water distribution systems. To ensure an economical and permanent design, anticipation of the development of the territory to be supplied should be made possible through the adoption of a definite scheme of community zoning. A revised method of determining required fire flows has been developed which should be applicable to all conditions. From our investigations, it seems that the required fire flow is the criterion upon which the pipe capacity of any gridiron system should be based.

FINANCING MUNICIPAL WATER SUPPLY EXTENSIONS[1]

By Caleb Mills Saville[2]

The purpose of this paper is to present a logical and practical method of financing municipal water main extensions. The several methods in more or less common use will be discussed, and their advantages and drawbacks commented upon, particular attention being given to the so-called "guarantee" and "assessment" methods. By means of example and reference to practical conditions, an attempt will be made to prove that the assessment method is, on the whole, the most equitable one for municipal use. Methods in use will be discussed, and citations from public utility commissions, together with some legal opinions, will be given. An outline will be given of the principles of the assessment method as employed at Hartford, Conn., and the results of its workings will be considered.

How to finance main water pipe extensions into new territory must be one of the oldest problems of water supply service and the perfect solution seems not yet to have been found. Tied up with it are an almost infinite number of conditions, some of local character and others of general application.

In the older states where the first public water supply systems had their beginnings it is easy to imagine the causes that led to the custom, which now is very prevalent, of requiring the applicant for a new extension of the system to give assurance to the utility that the cost of the work for his personal benefit would not become a charge on the other takers. Hence the basis of the so-called "guarantee" method had its origin, under which the petitioner or person desiring the extension guarantees a certain return on the cost in water rates or otherwise.

With reservations this method is applicable to both privately and publicly owned water systems. There are, however, many inequalities inherent in its administration from the standpoint of the consumers as a whole, from that of the petitioner, and from that of the utility, which are a cause of complaint.

[1] Presented before the Detroit Convention, May 24, 1923.

[2] Manager and Chief Engineer, Water Department, Hartford, Conn.

In looking through a tabulation in a recent magazine[3] it was found that of 656 municipalities, reporting on methods of financing water pipe extensions, 167 or 25.4 per cent depended on "bond issues," 34 or 5.2 per cent "by assessment," and the remaining 455 or 69.4 per cent used "surplus" or "appropriation" and similar means.

These are rather loose terms when critically studied, and meanings quite diverse can be assigned them by different persons who are not familiar with the individual case. It is probable that the majority of the places included in the list mentioned above require some guarantee of adequate income on the investment.

Whether the "bond issue" is redeemed by water department earnings or from the general tax levy is unknown. If from the former it is questionable practice; if by the latter it is poor accounting and may be unsound finance.

As a rule, however, municipal water department officials have little to do with methods of financing the department activities, and equally as well the majority of the members of city governments have little or no knowledge of fiscal relations.

In the case of those departments reporting "surplus" or "income" as the source of the funds used by them to finance their extensions, if these funds are applied to construction for the general improvement of the system they may be considered as being taken from the depreciation reserve, which might be an allowable procedure. If, on the other hand, they are used to pay for extensions into new territory for local benefit only, the application is improper, because it is taxing the whole number of rate payers for the advantage of a few.

Any method of paying for main pipe extensions into new territory is basically wrong which places the whole or any part of the cost of the extension on the consumers as a whole.

As to the method of financing capital expenditures out of return from water rates, in the case of water works operated by a municipality, the Montana Public Service Commission said (Kavanaugh vs. Town of Whitefish, P. U. R., October 26, 1922, E, p. 208):

> To ask for rates which not only pay operating expenses, depreciation, taxes, in the case of a private plant, and perhaps sacrifice taxes in the case of a municipal plant, but in addition a sum for capital accounts, violates every principle of rate making which is grounded on the theory and usually the fact that the consumers, as a class, are not the furnishers of capital.

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[3] American City, pamphlet No. 215.

Also (P. U. R., 1915 B, 331. L. C. 169, Cal. 318, 146 Pac. 640):

> The *expense* of making water extensions demanded of a water company by inhabitants of a municipality is not the controlling feature in determining the reasonableness of the demand therefor, because water rates as a whole must be sufficient to allow a fair, just and reasonable income on the property of the company devoted to public use, which would include such necessary expenditures; but an additional expenditure by the company, as an additional burden on the rate payers as a whole, should not be imposed for the benefit of a particular portion of the community where a reasonable necessity for it exists.

What is a fair and reasonable income on the property devoted to the public use? The most common rate of return allowed by public utility commission appears to be 8 per cent, although in some cases 6 per cent has been used. Considering the peculiar characteristics of water utility bonds, the last named rate seems altogether too low, when it is considered that these securities are most often locally owned and are not commonly listed in market reports. In the Hackensack Water Company Case, (Board of Public Utility Commissioners, N. J., April 28, 1917) the Commission said that "a return of 7 per cent on the base with a reasonable allowance for depreciation and operating expenses" was acceptable. In establishing the gross annual income, in addition to the fair return of 7 per cent, the Commission allowed as the annual depreciation and operating expense an amount equivalent to about 3.8 per cent of the total capital. These allowances ordinarily total about 12 per cent for a private company paying cash dividends to stockholders, while a municipally operated plant should be able to conduct its business for about one-half this return, depending on the state of its works and whether or not it has consumption and income proportional to plant value.

As to the method by which the cost of extensions is financed by "appropriations," meaning, it is presumed, from the tax levy, there is little or no sound excuse, unless it is that the payment is made in lieu of taxes and fire-protection service furnished to the city without other charge.

Even in such a case, public utility decisions are against such scrambling of accounts, and generally unite in holding that a water department, even if owned by the municipality, should receive cash for what it supplies to the city and in return should pay cash for what the city supplies to it.

Any appropriation from the tax levy that is not applied for the general welfare of the community is discriminatory and neither legal nor just. In view of the above, this method of financing extensions for development purposes is considered to be without adequate basis in fact, and therefore will not be given further consideration.

In the sense used above the word extension is taken to mean the installation of a water pipe of size sufficient to provide proper domestic and fire protection service for the immediate locality, with the water department assuming all cost in excess of the above which is necessitated for the good of the service.

The two methods which seem to qualify under the above condition are those designated as "guarantee" and "assessment," with their variants.

The guarantee method is proper if the payment in rates or otherwise received from the extension is sufficiently large to cover not only the proper portion of all maintenance and operating charges of the water department service, but also to pay interest and depreciation on the extension.

It is not proper if the guarantee is so small that either water is given away or the burden of the investment is carried by the consumers as a whole.

In some municipal instances the water rates would never meet the conditions named as proper, but the administration goes serenely on, and when the income of the department becomes too small to meet expenses rates are raised because of every reason but that which indicates poor bookkeeping and improper financial management.

In the opinion of the author the best and surest remedy for this condition is governmental regulation of municipally owned utilities as well as of those under private operation.

Through this means a uniform system of accounting is set up and the department not only properly segregates its own accounts and at the end of the period knows just where it stands financially, but it is able also to compare its costs with those of similar systems, which is an excellent incentive for getting the best work out of those on whom the responsibility for efficient and economical results rests.

As a general rule municipal utility works will seldom of their own initiative establish proper systems of accounting and the loose

methods of public finance are all too plainly apparent, but if a uniform method is prescribed by the state all must comply therewith, and the results are quickly in evidence.

In an article in "Public Works," July 6, 1918, p. 9, Mr. J. W. Ledoux stated his opinion, backed by certain mathematical deductions of a practical nature, that "under ordinary circumstances it does not pay to lay a water works distributing pipe extension in privately operated works unless the annual revenue obtainable thereon is considerably over 25 per cent of the cost."

There is, of course, no definite relation tying together the cost of supplying water, income from water rates, and the cost of laying main water pipes.

A municipally operated plant is supposed to supply water at cost, and by cost is meant the actual cost of operation, including interest, sinking fund payments and depreciation, plus a nominal margin sufficient to meet ordinary annual changes in cost of labor and materials, beside the variations in income that occur from year to year.

The depreciation fund cannot be called on to meet ordinary extension costs, because it is needed for replacements and capital expenditures for the good of the service as a whole. There is thus no surplus from income from which to finance the cost of ordinary extensions into new territory.

Under the method by means of which a certain percentage of the cost is guaranteed per year in water rents or otherwise, if the works are run at cost, other consumers pay either for the extension which benefits solely a limited locality, or else they pay for the water used in that locality. In either case this is discrimination and not allowable under the rules of equity.

If persisted in, this method would lead to bankruptcy, except that in a municipally run corporation there always may be recourse to increase in rates or to the tax levy to meet the deficiency.

As a matter of fact, what usually happens is that depreciation funds are conspicuous by their absence and when water rates are established they are made sufficiently large to discount the future. The margin thus created is a bank on which to draw until increased costs of running the department begin to approach the limit of income.

From the above it appears that the so-called "guarantee method" of financing main pipe extensions is not properly applicable to municipally operated plants.

On the other hand, the guarantee method is proper for privately run works because here there must be a good margin of profit in order to attract capital and continue in business. A portion of this profit, if so desired by the stockholders, may properly be invested in extensions which will yield still more profit.

So much for theory, but even municipally operated plants should be run at some margin of profit, and new money must be found for improvements in the ordinary course.

In the long run no business corporation, whether publicly or privately operated, can be run on a margin barely sufficient to meet operating and fixed charges. Unless earnings are sufficiently over the amount required to pay expenses, eventually there will be a breakdown.

At the meeting of this Association in New Orleans in 1910 the matter of financing water main extensions was quite fully discussed by Messrs. J. W. Ledoux, Miles J. Spaulding, and others. (P. 193 et sep., Proceedings 30th Annual Convention), and an article in "Public Works," July 6, 1918, by Mr. Ledoux, on this subject, contains many valuable suggestions.

Mr. Spaulding, as far as the writer knows, was the first member of the Association to call attention to some of the injustices of the present methods of financing main pipe extensions and to suggest that all ordinary distribution mains should be paid for by the frontage owners and not from the water fund.

In considering the guarantee method the basic proposition is: The extension should pay cost of supplying water, including fixed and operating charges on the original plant investment.

It is sometimes contended that, if there is plenty of water and the works, including supply lines, are adequate, all that is necessary is for the extension to pay operating costs, i.e., such costs as are a function of the amount of water used. This is discriminatory because it puts the burden on the other consumers of carrying fixed charges on the original plant and the extension draws a benefit without payment.

This method fails to take into consideration the fact that for every foot of extension of distribution system added to the plant there must sometime or other be a corresponding extension of the producing plant, the proportionate cost of which, under this method, the extension does not bear.

There is a difference to be recognized between sale of *surplus* water at a low rate and the *supply* of water to regular consumers. In the former case any income obtained over and above operating cost is a gain without obligation to the consumers as a whole, while in the latter case there is an obligation with no gain.

It is also contended that, if there is plenty of water and the works at present are adequate, all that is necessary is for the extension to pay a proper proportion of fixed charges on the original plant together with operating expenses. This also is discriminating, because it has laid the burden of the cost of extension made for local benefit on the consumers as a whole.

As to development, it is almost impossible to make so much as a moderately accurate estimate of the time which it will take for even a legitimate development to reach completion. From a rather hasty study of Hartford conditions, however, it appears that, with a bona fide intention for development in a moderately good locality, it may be reasonable to assume 50 per cent of full maturity in from two to five years and practically complete occupancy of the lots in five to ten years. What comparison without relationship there is between original cost of main pipe extentions, interest and amortization charges, water rates per consumer and income per front foot is readily found from figure 1. This diagram also clearly shows the fallacy of guarantee in water rates or otherwise as far as it affects a municipal plant operating at cost.

With a privately operated utility it seems proper to use the guarantee method, as the profit in the water rates should be sufficient to finance the extension after full development of the locality.

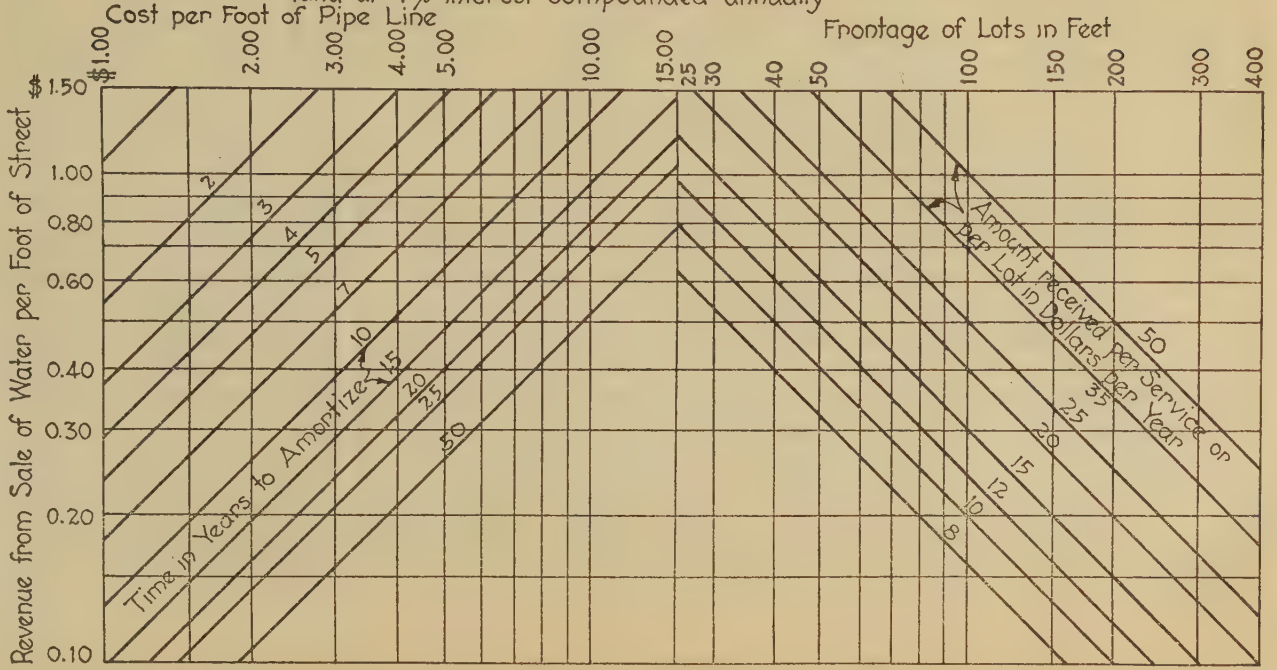
With a publicly operated utility run substantially at cost, there appears to be no argument for the use of this method unless it be for an amount in addition to water rates and sufficient to pay interest and amortize principal in a given term of years. This solution logically leads to the assessment method of financing water main extensions to be discussed later.

Some other objections to the guarantee method for use in municipally operated plants are (1) the difficulty in getting all abutters in a street to be participants in the guarantee; (2) the increased return in property valuation to all abutters on the extension at the expense of those who are uniting to undertake the burden; (3) the fact that through over-enthusiasm as to development it may be many years before a return is available sufficient to extinguish the

DIAGRAM SHOWING RELATION BETWEEN

(1) Revenue from sale of water per foot of street. (Average lot frontages and average amount received per year per service (or lot) varying.)

(2) Time required to amortize cost per foot of pipe line construction. (Amount of annual payment per foot of street and original cost of pipe line varying). It is assumed that 4½% annual interest is paid on pipe line cost and that balance of annual payment is placed in sinking fund at 4% interest compounded annually



guarantee, and (4) such combination of conditions may arise that the property may never return an income from water sufficient to meet the guarantee on the cost of the extension, even excluding cost of water supplied.

An excellent example of this last case has recently come to the author's attention. A large private estate was cut up into 32 building lots of ample proportions. On a guarantee of 10 per cent of the cost in water rates or otherwise, an extension was made during the winter of 1920 at the owner's request which cost $3.00 per linear foot, requiring a total annual payment of $476.10. Of the 32 building lots, 4 are so located as to take their supply from existing mains other than the extension, making it necessary to receive an average income in water rates from the 28 remaining lots of about $17 each. When the lots were sold, however in many cases the purchaser desired two lots for a single house, which would reduce the number of consumers. On three of these lots houses have been erected which have an average water payment of $28.16 per year. If the remaining lots are similarly developed the total received from water rates would be $394.24 per year, or $81.86 less than the 10 per cent guarantee. If on the other hand this particular piece of property had been developed for several large apartment houses, the income from any one might easily have covered the whole guarantee with the probability that much less expense would have been involved for the extension.

For purposes of illustration several streets in the Hartford, Conn., system, which are fully built up, are shown in the table below and the effect of the guarantee system worked out on the basis of cost of work.

In the first place it is interesting to note in this tabulation that although fully built up the gross income fails to reach 10 per cent of the cost by $10.60 per year, making a condition which under the usual form of the guarantee never would be extinguished. This is distressing from the view point of the investor, but is advantageous from that of the utility as it gives the amount of the difference as a payment toward amortization and interest.

STREET	LENGTH	DATE	NUMBER OF CONSUMERS	WATER INCOME	COST	INCOME PER CONSUMER
	feet					
1	695	1910	16	$206	$694	$12.90
2	653	1914	20	230	981	11.50
3	1167	1921	22	220	3464	10.00
4	562	1921	11	89	1680	8.10
5	653	1921	14	121	1950	8.60
6	335	1920	8	99	987	12.40
	4065		91	$965	$9756	$10.80

If this were a privately operated utility entitled to earn a fair return on the capital invested—say 7 per cent—the guaranteed income should be much larger than 10 per cent.

Based on the above pipe line data and making allowance for street intersections, 85 feet is a reasonable average frontage, with an average cost for pipe laying of $2.40 per linear foot and assuming water supplied at *cost.*

Applied to linear foot of pipe extension for municipal operation (at cost):

Interest and amortization (see figure 1)	$0.167
Cost of water = income (see figure 1)	0.254
Total expense	0.421
Water income—street wholly built up	0.254
Deficiency per linear feet of main pipe	$0.167

With every 85-foot lot there is an annual deficiency of $\frac{85 \times 0.167}{2}$ = $7.10 or $16.70 per 100 feet of street.

For income to meet the expense the guarantee instead of being 10 per cent or $0.24 per linear foot of street should have been $0.421 or $\frac{0.421}{2.40}$ = 17.6 per cent.

It is to be noted that an income equivalent to 10 per cent of the cost of the extension $0.24 per foot per year is 1.4 cents per foot of pipe *less* than the cost of supplying water.

If the application is made to a privately operated utility entitled to earn a fair return on the capital invested, say 7 per cent, the guaranteed income should be even greater before the extension is

warranted as an investment, although it is recognized that due to franchise rights and protection extensions must be made when the return in every case does not appear to be sufficient. As an abstract proposition, however, the following is presented, subject to modification for individual application:

For purposes of illustration a plant valuation of $9,500,000 is used with plant condition and maintenance and operating expense the same as before and an annual consumption of four billion gallons:

Return on capital investment $9,500,000 at 7 per cent	$665,000
Return per 1000 gallons $\frac{665,000}{4,000,000}$	0.164
Maintenance and operation expenses, including interest and depreciation per 1000 gallons[4]	0.155
Total income required annually per 1000 gallons	0.319
Total income required annually per 100 cubic feet	0.239

Increase in rates for private company $\frac{28.1}{15.5} = 1.8$

Average cost of water per lot $10.80 × 1.8		$19.44
Required for interest and amortization on extension		7.10
Total		$26.54
Yield per linear foot of pipe line for 85 foot lot at $26.54 payment		$0.620
Interest and amortization payment	$0.167	
Cost of maintenance and operation	0.254	
Required to produce 7 per cent on investment $\frac{\$10.80 \times 0.164 \times 2}{0.155 \times 85}$	0.268	0.689

Yield is thus less than the requirement by $0.069, or about 11 per cent while the requirement is $\frac{0.689}{2.40} = 28.7$ per cent of the same.

But this yield is $\frac{0.62}{2.40} = 25.8$ per cent of the cost of the extension.

The examples seem to bear out the statement of Mr. Ledoux that an extension is not warranted unless the income in sight is from 22 to 44 per cent of the cost.

There are several drawbacks to the guarantee method of financing main pipe extensions, among which are: That the percentage of

[4] Estimated cost, Hartford (Conn.) Water Department, 1922.

cost of supplying water varies with any change in lot length and character of the premises served, and another is the absence of fluid balance between the cost of construction and water income, and still another is that after the amortization period the particular customers on this extension should have their annual payments reduced by the amount of the completed amortization payment, otherwise they are either helping to finance other extensions or are paying a higher rate than produces what is considered a fair return on the investment. Allowance for the completed amortization of the extension would result in complicated bookkeeping and a continuation of payments after the requirement had passed would make the consumer a furnisher of capital which is contrary to public utility rulings.

Outstanding thoughts in what has gone before are (1) The inequality of the method as between consumers of the same class, and (2) The fact that a utility, whether publicly or privately owned, is usually working at a loss when it makes an extension on a guarantee of less than 15 per cent of the cost in water rates or otherwise.

In effect also the increased rates from the guarantee amount in the end to payment for the extension and a much more simple way of meeting the requirement is by means of the assessment method in the case of a municipally owned utility.

The assessment method, however, is not nearly as simple as it first appears, for there are complications which arise due to exemptions for corner lots, street intersections and public or non-taxable property, also how much above bare cost of installation should be charged to the extension for general distribution works such as excess size of piping in main feeders. On the whole, however, the assessment method divorces two essentials which have no practical relation to each other, viz., cost of the extension into new territory and cost of supplying water. As a general proposition it appears that an addition of from a quarter to a third of the cost of the extension is usually necessary to take care of the exigencies of the distribution system, leaving the cost of additions to other parts of the plant to be met by bond issue when necessity arises.

In presenting the subject of payment for water main extensions under the assessment method it is not my intention to go very far into the theory of this means of financing public works and that matter will only be touched upon in so far as seems necessary in forming a basis on which to develop the more practical aspects of this subject.

Legal information is of course available in the codification of the laws of general government and of the several states. Opinions and decisions are to be found in the reports of the State Public Utility Commissions or similar bodies, and are most widely available in the Public Utilities Reports Annotated (Rochester). Most excellent treatment of a semi-legal character may be found in "Theory and Practice of Special Assessments" by Mr. J. L. Van Ornum Mem., Am. Soc. C. E.,[5] while more popular presentation may be found in an article on "Special Assessments" in the National Municipal Review.[6]

A careful analysis of the subject of assessments, particularly as relating to sewerage may be found in two dissertations by Mr. F. Herbert Snow, Mem. Am. Soc. C. E., one in his report upon a sewer tax for the City of Brockton, Mass.[7] and second a paper on "Sewer Assessments" before the Boston Society of Civil Engineers.[8]

While the matter of financing water supply work is not strictly analogous to that applicable to that of sewerage, still there is sufficient similarity to warrant close study of the methods developed in connection with the latter to make it worth while to give them consideration. The use of the property assessment processes for financing sewerage work is well-nigh universal and there seems to be no inherent reason why it should not be applied as well to water supply work. Undoubtedly at the beginning in most cases the municipality has bonded itself to raise funds for undertaking the work and in most cases also it is probable that for the first few years money at least for payments to sinking fund to amortize these bonds and perhaps also for interest on them comes from the tax levy.

The following excerpts seem of sufficient authority to attest the legality of the application of the method of special assessment for defraying the cost of the water main extensions by municipalities.

By definition an assessment is "the official apportionment of taxes." Taxes may be either general or special as the object is for the general interest or for the advantage of a certain portion or district. A special assessment has been defined[9] as "a compulsory

[5] Trans. Am. Soc. C. E., vol. 38, 1897, p. 336 et seq.

[6] February 1922. Publication by National Municipal League, 261 Broadway, N. Y.

[7] Journal Assoc. Engr. Soc., Jan. 1897.

[8] Report of the Sewerage Commissioners, Brockton, Mass., 1894.

[9] Quart. Jour. Econ., April, 1893.

contribution made once and for all to defray the cost of a specific improvement to property, undertaken in the public interest and levied by the government in proportion to the special benefits accruing to the property owner."

CITATIONS RE SPECIAL ASSESSMENTS

1. *Improvement must be of special local benefit.*

. . . . To make the special assessment valid, its purpose and effect must be to benefit the property in the vicinity of the improvement, and not to the public generally. . . . .

Ref.: 10 La. Ann. 57; 69 Pa. 352.

2. *Assessment in proportion to benefits.*

. . . . Burdens in excess of benefits . . . . must be borne by general taxation. . . . .

Ref.: 12 Colo. 593.

3. . . . . A lot, though below the grade of a sewer, has to pay its portion of the assessment, as it will be benefited whenever it shall be filled. . . . .

Ref.: 69 Texas 180; 7 Cush. (Mass.) 277.

4. *Details of Apportionment.*

. . . . Corner lots, having thus a double frontage, may be properly assessed the total amount determined by their linear extent on both streets, where both streets are improved; though the usual way is to abate a certain percentage of the assessment on one front, and there are cases where, when a corner lot has its longer dimension abutting on the improved street and its shorter dimension on another, it was held that the lot should be deemed as fronting on the improvement only to the extent of its shorter dimension, but the usual rule in such cases is that the frontage of a corner lot is "its frontage upon the improvement," although the condition of the lot and its improvements make its proper front (as usually considered in other connections) on the cross street. . . . .

Ref.: 35 Pa. St. 75; 32 Iowa 271; 140 Ill. 402; 50 Ohio 471; 131 Mo. 190.

5. *Principles Affecting the Validity of the Levy.*

. . . . The law must require notice to them and give them the right to a hearing and an opportunity to be heard. . . . .

Ref.: 74 N. Y. 183, 188.

6. . . . . The power of taxation, especially for local improvements, is the highest attribute of sovereignty. . . . . Such statutes must be construed with the greatest strictness. But in the absence of fraud or mistake the administrative acts and discretionary decisions of this Board are authoritative and final; and "The decision of the Board . . . . is conclusive." . . . .

Ref.: 4 Hill (N. Y.) 76; 59 Ark. 344, 363; 33 Minn. 295, 304.

7. . . . . There may also be a successful defense if there is no possible benefit to the property; as where the owner of a corner lot had applied to the city council for the use of water and had paid for the pipe laid in consequence along one front of his property, he was held not liable to assessment for pipe afterward laid along the other front without his petition. . . . .

Ref.: 14 Bush (Ky.) 24; 86 Pa. St. 498.

8. . . . . Neither will the fact that a property owner, assessed for the construction of a public sewer, had previously constructed a private sewer (sufficient for the needs of his property and with the assent of the city) relieve him from such assessment, even when a municipal building had connected with the private sewer.

Ref.: 81 Wis. 326; 168 Pa. 105; 154 Ill. 23; 138 Ill. 295.

In the application of the method of special assessment the following conditions should be observed as being equitable and reasonable:

1. The Water Department should determine if the extension is required by public convenience and necessity and when so decided should establish a definite means for assessment based upon the average cost of laying a water main of proper size to supply both domestic and fire protection service to the street in question.

2. The Water Department (for the municipality) should pay that proportion of the cost which is for general benefit, usually from one-fourth to two-thirds the cost of the extension.

3. Two methods seem applicable for payment of the assessment:

(a) By a frontage tax against all abutting property which may be served by the extension.

(b) By an "entrance fee" for the privilege of connecting with the water main and based on lot frontage.

4. The assessment should be so regulated that the total amount may be paid in full or in installments during a fixed term of years at the option of the person assessed.

Because of the inequalities that were patent in the guarantee method, and because of the many complaints that were made both by house owners and local developers, the Water Department of the City of Hartford, Conn., has recently (Jan, 1922) changed from the "guarantee" to the "assessment" method of financing main pipe extensions. As a general proposition the plan has worked very well and there seems to be no cause for regret in the change. Some of the considerations leading up to this action were the following:

1. A lot of land increases greatly in value with the installation of a water main in the street on which it fronts. It therefore seems more just for the land owner to bear the cost of the improvement than for other water consumers throughout the city to be taxed for it.

2. This method tends to equalize the cost of the improvement by distributing the cost over all property benefited rather than, as under the old method, placing all of the burden on a few property owners.

3. A healthy development of real estate is provided by enabling a property owner to utilize his holdings without being held up by the expense of the water installation when other owners were reluctant or refused to sign a guarantee.

4. Real estate development is aided by making it possible for the owner to include equitably in the price of his lots the cost of the water installation.

5. By this means cost of supplying water and cost of water main extension are separated and each is apportioned to the consumer in proportion to value received.

6. The cost of the extension is recognized as a capital expenditure and can be properly met as such by a bond issue, with interest and sinking fund entirely met from the payment of the assessment, while the cost of supplying water, being an operating and maintenance charge, is met from water rates.

While there is no disposition to return to the abandoned method there are many problems that have arisen which are now in process of solution and a recitation of some of them may be of value in helping others to save time and trouble in avoiding them when the assessment method is adopted by them, as it seems probable it eventually will be.

The matter of what portions of the cost should be borne by department and by abutting property has been a cause of much discussion. The final decision was that the department would assume:

1. All cost in excess of the average cost of a 6-inch main.
2. The cost of street intersections.
3. The cost of the installation in front of public property.
4. The cost of 75 feet frontage on corner lots when there was a main on the other side.

Some questions which have arisen but probably have not yet been finally disposed of are:

1. Whether or not the corner lot exemption should begin at the actual property corner or at the building line where one is established.
2. Assessment against frontage of irregular lots when one end is so narrow as to be impracticable for building.

The authority under which this method for financing main pipe extensions is carried on is in an act of the General Assembly authorizing the Common Council of the City to enact an ordinance providing for it. This ordinance was as follows:

Be it ordained by the Court of Common Council of the City of Hartford;

Section 1. Whenever in the opinion of the Board of Water Commissioners of the City of Hartford, public necessity and convenience require the extension of any main pipe and shall vote to make such extension, said Board shall assess the cost of such extension against the land found by said Board to be specially benefited thereby abutting upon the road, street or highway in which such main is to be laid, with the buildings on said land, in proportion to the frontage of said land upon such road, street or highway.

Section 2. Before said Board shall vote to make any such extension at least ten days written notice of the proposed extension shall be given to the owner or owners of the land and buildings upon which the cost of such water mains may be assessed and of the time and place when objections to such extensions will be heard by said Board and notice thereof shall also be published twice at least, in two newspapers published in the City of Hartford.

Section 3. Upon the final completion of the construction of such water main, said Board shall give written notice thereof to the owners of the land and buildings assessed thereof and that said assessments are due and payable from the date of such notice. The amount so assessed shall be a lien upon the lands and buildings on account of which it was assessed, which lien shall commence and attach to said land and buildings from the time of the passage by said Board of the vote to extend said water main, but shall not remain a lien thereon for a longer period than three months from the final completion of said work unless said Board shall within that time lodge with the Town Clerk of the Town within which such land and buildings are situated for record, a certificate signed by the Secretary or other authorized representatives of said Board describing the premises and the amount assessed thereon.

Section 4. Said Board shall in no case vote to extend its main pipe in accordance herewith in any road, street or highway that has not been legally accepted by the city or town within which such road, street or highway is located or in any road, street, or highway until the same has been rough graded to an established grade.

Section 5. Said Board in determining the cost of any such extension shall use the average cost to said Board of laying six-inch pipe in the City of Hartford during the preceding calendar year provided that such average cost does not exceed the actual cost thereof.

Section 6. The owner of any land and buildings assessed for the cost of main pipe extensions as aforesaid may elect to pay the amount assessed as aforesaid in ten annual installments with interest on the unpaid balance thereof, provided that notice of such election shall be given to said Board within thirty days after notice shall have been given of the completion of the work.

After working under it for a year and with every effort made to keep cost of construction at a minimum it was found that the average cost of laying 6-inch water pipe was $2.35 per linear foot, including overhead. When it became necessary to establish the price for 1923 it was seen that prices of materials and labor were to be much higher than in the previous years and if the average cost for 1922 was made the basis for the ensuing year the department stood to pay a much larger proportion of the total cost than in the previous years. After some study of conditions it was decided to use the average cost for the previous five years. Working on this basis a base price of $3.00 per linear foot for the year 1923 was established and an ordinance enacted to this effect. Due in part to the oppor-

tunities of this method and in part to the lagging of ordinary building construction due to the high prices of the previous year there was something resembling a boom in building during 1922 and much main water pipe was extended.

The total cost of this work was $194,977 of which the Water Department absorbed $45,987 or practically one quarter, due to the various causes mentioned above. Besides this expenditure on account of capital, the Water Department also became the financial agent for promoting these extensions, finding the funds and carrying the investment until paid under the terms of the ordinance. It is readily seen that while a revolving fund would be created that in ten years at most would return sufficient to care annually thereafter for the new investment, yet up to that time the department must find the funds with which to finance the work. After some consideration the best plan seemed to be to issue serial bonds for a ten-year period. By this means interest and sinking fund would be met from the extension payment and in addition a substantial sum would be available at the end of ten years for current capital expenditures, the details of which on the basis of $150,000 annual bond issues are:

An annuity of $1.00 at 4 per cent compound interest in 10 years would accumulate $12.006.

$$\frac{\$150{,}000}{12.006} = \$12{,}493.75.$$

In round numbers $12,500 per year with interest at 4 per cent compound annually would in 10 years amount to $150,000.

Total interest paid in 10 years, $150,000 at 4 per cent	$60,000	
Total interest received on unpaid balance in 10 years	40,500	
Excess interest paid		$19,500
Received from assessments in 10 years	150,000	
Paid into Sinking Fund, $12,500 × 10 years	125,000	
Excess money received		25,000
Total excess received over amount paid in 10 years on each issue of bonds		$5,500

The guiding principle of this paper is intended to be the establishment of a sound business policy applicable to the plan of water department activity herein discussed.

A business which does not support itself in all its parts is in a sense parasitic and subsists because some of its portions pay the difference between cost and income. In present day management a business must support itself or be scrapped. The rights of a customer should be safeguarded, but it is not his right to get something for nothing which ultimately increases an unequal burden on some other customer. The necessity of payment for value received is often overlooked in rate fixing and uniform prices often produces disproportionate burdens that it was the intent to equalize.

As to the operation of the assessment method in Hartford, Conn., for the financing of main pipe extensions, table 1 is a résumé of of the method employed in 1922, with the relative distribution of costs between the work done by hand labor and that with a Keystone Excavator. Leadite was used in making the joints.

Allocation of the total amount of pipe laid in 1922 is given in table 2.

Exemptions and allocation of the amounts paid by the Board are shown below:

	MAINS COSTING LESS THAN $3.05 PER LINEAR FOOT	MAINS COSTING MORE THAN $3.05 PER LINEAR FOOT	TOTALS
Assessable frontage, feet	74,083	34,135	108,218
Exemptions, feet	5,858	5,731	11,589
Frontage exemption, cost	$7,011.66	$8,739.78	$15,751.44
Street intersections, cost	4,173.78	7,879.93	12,053.71
Oversize and construction difficulties (cost)		18,182.43	18,182.43
	$11,185.44	$34,802.14	$45,987.58

The method used during 1922 for ascertaining the amount of assessment was to determine the actual cost of laying pipe per linear foot by dividing the total cost of the work by the total length of water pipe laid, i.e., by the distance along the axis of the pipe, from the center of the pipe from which the extension was made to the extreme end of the new pipe line. After determining this unit cost it was divided by two (for application to both sides of the street) and the result multiplied into the respective lot frontages which were not exempt by vote of the Board.

By this method the cost of pipe laying in all street intersections and crossings, as well as in front of exempted property was assumed by the Board.

Exemptions have included corner lots up to 75 feet when there was a water main already laid by the other side, also property used for public purposes.

In addition to the above, the Board has borne the cost of all work exceeding the base price of $3.05 per linear foot whether the same was due to matters of construction, to the installation of pipes of larger size than the standard 6-inch, or to other abnormal conditions.

By this method it appears that approximately $\frac{1}{4}$ of the cost of the main pipe extension work is borne by the Water Department and $\frac{3}{4}$ of the cost by abutting property owners.

During the year, two other methods of apportioning cost have been suggested, both of which are based on placing the entire cost[10] on property abutting on the portion of the street in which the pipe is laid.

One of these methods would apply the total cost of the work to the same assessable frontage as at present; the other would distribute the total costs of the work over the total frontage with no exemptions for corner lots or public property.

Neither of these propositions will provide entire relief, namely, to place the whole burden of cost on the abutting property owners, because of the conditions that the *average* cost of laying 6-inch pipe the previous year is set as a maximum above which the cost must be carried by the department, while the abutter gets the benefit of cost below this limit.

This condition could be attained if the actual cost of pipe laying could be assessed against abutting property. This, however, brings in many complications which might lead to more trouble and possible expense for the Board than the present method. For example, it would be impossible to make even an approximate estimate of what would be the probable cost of the work without a very thorough investigation. Again, the cost of a 6-inch pipe extension seems to be as much as it is equitable to place on individual consumers, yet during 1922 only about 23 per cent of the pipe laid was of this size, the remainder being of larger size because of necessities of the service.

[10] Not exceeding base price.

TABLE 1

Summary of main pipe laid 1922

Detailed costs of pipe laid under assessment plan

SIZE	LENGTH	LABOR COST + 15 PER CENT		MATERIALS COST + 10 PER CENT		TOTAL COST	
		Total	Per foot	Total	Per foot	Total	Per foot
inches	*feet*						
6	14,751.2	$12,498.58	$0.85	$16,267.35	$1.10	$31,726.56	$2.15
8	42,238.8	42,151.74	1.00	72,055.35	1.705	125,729.39	2.98
10	2,272.2	3,117.72	1.37	5,868.21	2.58	9,884.62	4.35
12	3,665.5	6,645.79	1.81	12,400.44	3.38	21,282.67	5.81
16	872.0	1,791.62	2.055	3,950.73	4.53	6,316.59	7.24
Totals.....	63,699.7	$66,205.45		$110,542.08		$194,939.83	

Note: Column 7 = Column 3 + Column 5 + 10 per cent; Column 8 = Column 4 + Column 6 + 10 per cent.

Amount assessed.....	$148,989.97
Amount paid by Board.....	45,987.58
	$194,977.55
Excess frontage assessment on west side of Dennison Street.....	37.72
	$194,939.83

Total assessable frontage = 108,218 feet.

Comparisons of cost—machine vs. hand labor

SIZE	LABOR (KIND)	LENGTH	LABOR		MATERIALS		TOTAL COST	
			Total	Per foot	Total	Per foot	Total	Per foot
inches		*feet*						
6	Machine	9,658.8	$7,047.61	$0.73	$10,323.29	$1.07	$19,131.30	$1.98
6	Hand	5,092.4	5,450.97	1.07	5,944.06	1.17	12,595.26	2.475
8	Machine	22,824.4	19,911.87	0.87	39,127.78	1.715	65,094.87	2.85
8	Hand	19,414.4	22,239.87	1.145	32,927.57	1.70	60,634.52	3.125
10	Machine	1,347.4	1,429.74	1.06	3,267.07	2.425	5,166.59	3.835
10	Hand	924.8	1,687.98	1.825	2,601.14	2.81	4,718.03	5.10
12	Machine	1,807.1	1,976.29	1.09	5,719.34	3.165	8,565.12	4.74
12	Hand	1,858.4	4,669.50	2.51	6,681.10	3.595	12,717.55	6.84
16	Hand	872.0	1,791.62	2.055	3,950.73	4.53	6,316.59	7.24
Totals.....	Machine	35,637.7	$30,365.51		$58,437.48		$97,957.88	
	Hand	28,162.0	35,839.94		52,104.60		96,981.95	

While it would be perfectly logical to assess the total cost of laying a 6-inch pipe against abutting property, it would undoubtedly result in much discussion and many difficulties for the Board to settle, due to the extreme variation which might result from the character of the ground, whether rock, sand, water or other conditions. It would be somewhat difficult also to determine just what would be the cost of laying a 6-inch pipe when a larger pipe was laid under difficult conditions. Yet by the theory of assessments on property actual cost of work done for that particular piece of property may not be exceeded.

TABLE 2

Main pipe laid during 1922

Frontage, exemptions, etc.

	6-INCH PIPE IN HARTFORD ONLY	6-INCH PIPE IN HARTFORD AND WEST HARTFORD	ALL SIZES HARTFORD AND WEST HARTFORD
Total length of pipe laid, feet	5,753.8	14,751.2	63,799.7
Total frontage in feet	11,006	28,494	119,807
Exemptions:			
Street corner lots and public property	*1,514*	*2,264*	*11,589*
Assessable frontage	9,492	26,230	108,218
Street intersections	561	1,068	7,876

The following suggestions are made in a tentative way for financing the cost of a water supply system

1. Let the District bond itself for a sufficient amount to install the main features of the water supply system, such as collecting systems, pumping plant, purification plant, supply mains and similar features.

2. Let those who desire the water pay a benefit assessment equivalent to the cost of installing a 6-inch pipe to supply their property, whether or not the supply main passes their property and in proportion to the respective lengths of the several properties where there is more than one applicant, each previous contributor to get a proportional repayment as other takers come onto the line thereafter.

2a. A variant of this would be to take a guarantee from one who desired the extension that he would pay an amount annually equiva-

lent to 10 per cent[11] of the cost of installing a 6-inch pipe to serve his premises in addition to the water rents.

If there are any persons on the line of pipe unwilling at the time to sign the guarantee, refuse to allow them to connect thereafter until they do agree to sign to pay their share of the annual payment, proportioned on the number of feet property fronting on the street in which the pipe was laid.

No rebate should be given to previous guarantors, on the assumption that their previous payments were for value received at that time.

3. The proposed water taker should pay for the service installation from the street line to his house.

4. The Water District should pay for the service connection from the street main to the street line, and for the meter and its installation.

On this basis a guarantee is not sound financially unless it provides (using 15 years as a reasonable time for the cost to be amortized) for an annual payment of 5 cents on the dollar of investment, which is the amount which put at interest annually at 4 per cent compound interest will amount to $1.00 at the end of 15 years.

Payment made on this form of financing main pipe extension costs should be made in excess of water rents; i.e., water rents should not be allowed to be made a part of the payment for main pipe extensions.

Before leaving the subject of assessment as applied to financing main water pipe extensions it seems desirable to mention some of the water departments where this method is in use:

Philadelphia, Pa. (C. E. Davis, Chief of Bureau): "Philadelphia assesses property owners for water pipe laid in front of their premises at the rate of $2.00 per front foot, as per ordinance approved April 14, 1920."

Yonkers, N. Y. and other municipalities in this state (A. W. Kingsbury, Chief Clerk), Section 8, Art. VIII, Suppl. Charter 1918: "In addition to water rents provided for in this section there shall be a frontage tax of five cents a front foot in each and every year on all real estate lying along or facing either side of the street or alley in which a water main is now laid or shall hereafter be laid." This frontage charge has been upheld by the Supreme Court of New York.

Detroit, Mich., makes a charge of 25 cents a foot against abutting property as the abutters share of the cost.

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[11] The 10 per cent guarantee in addition to the water rents is based on 5 per cent interest on the principal and 5 per cent additional for a sinking fund to amortize the cost in 15 years at 4 per cent compound interest.

Minneapolis, Minn., assesses against abutting property owners one-half cost of laying a six-inch pipe.

St. Paul, Minn., assesses a charge of 10 cents per front foot per year against property for 10 years. (Note: at 4 per cent compound interest this payment would amount to $1.20 at the end of the period, equivalent to $2.40 per foot of pipe laid.)

Milwaukee, Wis. (H. P. Bohmann, Superintendent): "All assessments are based on the cost of laying a six-inch main. An estimate is made early in the year, after contracts have been let for water pipe, hauling and laying. Cost records are kept on each job. In case the cost of laying six-inch main exceeds the estimate made early in the year, the property is assessed only the amount fixed by the estimate—the difference being paid out of the Water Fund. When the cost is less than the estimate the property is assessed the actual cost of laying the main. Street and alley intersections are paid for out of the Water Fund. When larger mains are laid than six-inch the property is assessed on the basis of laying a six-inch main, the excess cost being paid out of the Water Fund.

"Corner lots are given a deduction of one-third of the two frontages."

Altoona, Pa., makes a frontage charge of 25 cents per front foot when the main is laid.

Pasadena, Calif., makes a frontage charge of 50 cents per front foot when the main is laid; the department bears the excess cost.

Jacksonville, Ill., and other cities of this state lay water mains under the same act as they do sewers and street paving, viz., the "Special Assessment Act."

City of Seattle, Washington, lays water mains under city ordinance which covers the method of laying assessments.

Duluth, Minn., assesses cost of water main extensions on the basis of a formula designed to make the construction self-supporting, assessing 8 per cent of the cost each year against abutting property for 15 years and crediting to this assessment one-half the rates paid for water.

Pennsylvania Water Company (W. C. Hawley, Chief Engineer) has a bonus system which seems to work out very well.

Decatur, Ill., finances water main extensions in accord with the State law out of a special assessment levied against property served.

Cleveland, Ohio (F. B. Crowley, Registrar): Water mains financed by special assessment against property deemed to be benefited under one of the following methods:

1. Percentage of the tax value of the property.
2. Proportionate to the benefits resulting from the improvement.
3. Front footage of property bounding or abutting upon the improvement.

Washington Suburban District, Md.: A logical and seemingly well worked out plan for financing both water and sewer cost has been applied by Messrs. Robert B. Morse and Abel Wolman of this Association, and is described by them in Eng. News-Rec., June 2, 1921.

"By this method the installation of both water supply and sewerage systems is paid for by a combination property tax, annual front foot assessment, house connection cash payment, meter service charge and water consumption charge."

APPENDIX "A"

Water main assessments for extensions—corner lots

1. Reading, Pa. Corner lots, exempt $\frac{1}{3}$ of the assessment on total length on both streets.

2. Bristol, Conn. Exempts 100 feet on total length.

3. Philadelphia, Pa. Exempts $\frac{1}{3}$ the length of one of the fronts, but in no case shall the allowance exceed 50 feet on any corner lot.

4. Washington, D. C. Exempts 100 feet on total length.

5. Milwaukee, Wis. Exempts $\frac{1}{3}$ the length on both sides.

6. Allentown, Pa. Exempts $\frac{1}{3}$ on the longest side, but in no case shall the allowance exceed 60 feet.

7. Minneapolis, Minn. Assessment laid against long side, short side exempt up to 65 feet. Full payment made on side first covered and adjustment made when other side is covered.

8. St. Paul, Minn. Short side only assessed.

9. Washington Surburban Sanitary District. Assesses only on side the building faces.

10. In some cities no exemption is made on corner lots.

11. Hartford, Conn. Sewer Assessment—Short side assessed, long side exempt up to the normal depth of lots in the section, say 125 to 175 feet.

APPENDIX "B"

Extracts from Page and Jones "Taxation by Assessment"

Art. 11, p. 19, Special Assessments: "It is a local assessment imposed occasionally, as required, upon a limited class of persons interested in a local improvement who are assumed to be benefited, and it is imposed and collected as an equivalent for that benefit and to pay for the improvement." City of Bridgeport vs. N. Y. N. H. & H. R. R., 36 Conn. 225, 262, 263, Am. Rep. 63 (T869).

"The foundation of special benefits for public improvements is the special benefit derived by owners of property over and above the rest of the community." Newell vs. City of Cincinnati, 45 O.S. 407, 424. 15 N.E. 196 (1887).

Art. 668: A general conservative rule as regards special assessments authorized by the legislature seems to be that "the legislative allocation is to be regarded as final and conclusive except as to cases where actual injustice is shown to exist and where assessments are levied greatly in excess of or out of proportion to the actual benefits."

Art. 670: The legislature may leave it to the public Corporation which is to levy the assessment to determine the method. In that case "it has been said that the public corporation is restrained only by the constitution and laws of the State and by the doctrines of the common law which requires municipal ordinances to be reasonable."

When the legislature provides that the question of the existence, amount and apportionment of benefits shall be determined by the public corporation which is to levy the assessment or by some designated public official or set of officials, it is said in many cases that the determination of said public corpora-

tion or public officials upon the question of the existence, amount and apportionment of benefits is final and conclusive.

Art. 708: Assessments of a fixed sum per front foot have been applied as long as they do not exceed the cost of the improvement.

Art. 709, p. 1229: "If land on one side of the street belongs to the county and cannot be assessed, the entire cost of improving such portion of the street cannot be assessed upon the land on the opposite side of the street."

DISCUSSION

Caleb Mills Saville: I think the method of assessments has given very good satisfaction. It is apparently more pleasing to the people than the guarantee method has been, for several causes. Under the old guarantee method when a man built a house or owned a lot 1000 feet down a new street from a water main, he would petition to have a water main laid in that street, guaranteeing 10 per cent of the cost in water rents or otherwise. He might go to various other owners on the street and ask them if they would sign the petition with him. Some would sign and others would not. In consequence the signers might have to bear the whole burden of the guarantee while the other property owners had the benefit without the obligation, because when the main was laid it became public property.

A Member: Does your department collect the funds or is it done through the city?

Caleb Mills Saville: Answering the gentleman's question, we collect all the funds and have the use of them. We are practically a private corporation. We have a charter of our own, although it is a municipal corporation. The only connection we have with the city is that each year the Mayor appoints two members of the Board who are confirmed by the Council; after that the board functions independently, using all its funds as it deems proper, and can sue and be sued. If we change the rates, they have to be approved by the Council, as does also the bond issue, which becomes then an obligation on the city.

The method applies to extensions inside the city limits, everything that we have jurisdiction over; there are one or two communities that we supply on the same terms and conditions that we supply our own. There are one or two communities in which

our water supply reservoirs are located and under our charter we are required to furnish them with water on the same terms as the city. We do our work entirely with city employees.

As to payment for laying pipes in the newly annexed territory which has to be supplied with water facilities, we supply it through a master meter at the city line the same as to any private consumer. If the section is annexed to the city and becomes an integral part of the city, we make an appraisal of the local works and the Hartford Department purchases the system. In the case of an annexed section having no water mains, we should go on the same basis that we would in the city. That would be a part of the city and we should lay pipe in it and assess against the frontage.

Each frontage is assessed separately irrespective of the owner. This applies, of course, to property annexed to the city. Property outside the city is cared for as hereinbefore described.

If anyone assessed refuses to pay an assessment, a caveat is filed as soon as the Board decides to put the pipe in. A period of three months may then elapse and after that a lien is applied that takes precedence over everything.

Answering Mr. Gibson's question how we determine when an extension is to be made, that is a question that lies with the Board of Water Commissioners. A public hearing is held; ten days notice is given by advertisement of a public hearing and everyone for or against is warned to attend that hearing. The Board then takes it under advisement, and if, in the judgment of the Board that pipe should be laid, it is laid. The determining factor is only in a partial degree the economic return to the department, as the property pays for most of the improvement. The only matter of vital interest to the Board is a prospective return sufficient to take care of the portion of the cost absorbed by the Board. The money collected is credited to capital account.

Answering Mr. McIntyre, it is a law that was passed by the legislature amending the charter of the city of Hartford, Connecticut, for the purpose of doing this very thing. It is also a state law in many other states; Washington, I think, has such a law, and a great many of the states in the middle west have such laws. There are quotations in the body of the paper as you will find.

S. L. Etnyre: The Iowa water works and the Iowa Section of the American Water Works Association have a very similar bill before

the legislature at the present time. As I understand the gentleman speaking, there is no refund.

CALEB MILLS SAVILLE: No.

PRESIDENT CRAMER: That is another proposition than the one we have been talking on. There is no refund whatever, just simply an assessment against the property.

HENRY P. BOHMANN: Milwaukee has laid 600 miles of water mains and has collected in round figures approximately $3,000,000 from the abutting property owners for water pipe assessments. This represents the extension of the system during a period of 50 years, and in no instance has any property owner during the 50 years ever attacked this assessment. An estimate is made at the beginning of each year of the cost of laying a block of minor water pipe, which is a 6-inch pipe. After contracts are let for water pipe and the laying of same, this estimate is made. When the water main is laid, and the actual cost exceeds this estimate, the difference is borne by the water department. If the cost is less then the abutting property owners pay the actual cost. All street intersections are paid for out of the water fund, and the excess cost of laying the mains, if larger than a 6-inch main, is paid out of the water fund. Corner lots are given a reduction of $\frac{1}{3}$ of the two frontages. Extensions are made at the request of any property owner and it does not require a certain percentage of street frontage to have this extension made. The Commissioner of Public Works introduces a resolution that the main be laid. The main is then laid and the assessment placed on the tax roll, together with other assessments and the assessment for the property. This has proven very satisfactory; no one has ever attacked the assessment, and it seems to me after an experience of fifty years in the city of Milwaukee that we must assume that it is pretty nearly right.

H. F. BLOMQUIST: There are two different principles involved in the question: One is to finance water main extensions by ordinary special assessments as are made for other local public improvements, the other, to pay for extensions out of income from water sales. Many states permit municipally owned water works to make special local assessments against benefited property for such extensions, and this method is extensively used. Some cities make direct

special assessments, and others collect frontage tax for a period of years. The laws of the State of Iowa do not now permit special local assessments for this purpose, but permit tax levies to be made uniformly on all property of the city as a part of the budget for city government expenses. Water main extensions in Iowa, therefore, must be made from the income for water service, or from tax levies spread uniformly over the whole city. The latter is not much favored because it taxes property promiscuously for the benefit of some local section. Extensions in our state have, therefore, most commonly been paid for by income from the sale of water.

When construction costs increased, as they have the past few years, and cities increased in population faster than before, making a greater demand for water main extensions, it became difficult to finance them. To help overcome this difficulty a bill was introduced in the Iowa legislature as explained by Mr. Etnyre but failed to pass. The proposed law was worded so that it would be possible to make the change rather gently from the old way of financing by income from sale of water, to that of special assessments. It really did not propose special assessment as the ultimate means of financing as I shall explain later.

It might seem to be unfair discrimination to commence arbitrarily to make property owners pay for main extensions by special assessments, also charge them the same rate for water as others who have formerly had the mains laid in front of their property at the cost of the water department.

In new additions the income from water sales for many years, sometimes, is not sufficient to pay interest charges on the necessary investment. But platted vacant property in a city is generally increased in value as soon as water service is available, because of better chances for sale and development.

The purpose of the proposed law was simply to provide that vacant property should carry its portion of the investment for water mains, until it had a water consumer on each lot. The wording in substance, was as follows:

> When water main extensions are made by municipally owned water works, an assessment may be made against the benefited property not to exceed the cost of laying a six-inch water main in front of said property, and later the municipality may refund to the owner when he becomes a water consumer, the amount paid of such assessment not to exceed the equivalent of 50 feet of frontage for each connection.

The effect would be that owners of vacant property would carry the investment in water mains fronting on their property until a connection is made for each 50 feet of such property. Many operators in Iowa feel that it would solve the problem of financing main extensions in sparsely settled additions, and still adhere to the principle now in use of paying for them from the sale of water.

CALEB MILLS SAVILLE: A municipal water works is, theoretically at least, supposed to sell its water at cost. Selling its water at cost means practically no profit, and having no profit, theoretically again, there seems to be no way where you can find the money to finance your main pipe extensions. If there is a profit, it seems to me that there is discrimination, because you are making all your consumers pay for pipe that you are going to lay in front of some other man's property and be a special benefit to that property at the expense of the other water takers.

JOHN N. CHESTER: I do not think Mr. Saville, if he would analyze his last statement, would make it. There are numerous municipalities that make a profit on their water. The cities of Erie, Pa., Shreveport, La., and Meridian, Miss., all sell their water at a profit, and it is easy to justify, at least, the annual depreciation on the plant, set aside as a depreciation fund to be reinvested in the extension of the plant. That is good business in private affairs, and anything that is good for a private concern ordinarily fits fairly well in a municipality. Now Mr. Hazen was the author of the statement once made before this Association that he had never yet looked into the affairs of any water department, private or municipal, that was not starved financially, and he always expected to find them so when he found low rates being charged. That is about as near Mr. Hazen's words as I can quote. It coördinates absolutely with my experience, and I do not believe that any water department ought to operate without sufficient rates to pay its operating expenses, interest on all bonds outstanding, the sinking fund on bonds outstanding, and a reasonable amount for ordinary extensions which you can call depreciation or what you may.

P. J. HURTGEN: Mr. Bohmann, of Milwaukee, told you of the manner in which they made assessments in Milwaukee. Milwaukee is the only first class city in Wisconsin. There is on our statute

books a law that was passed two years ago which provides that cities other than cities of the first class can assess for water mains to the extent of the cost of a 6-inch main. Up to two years ago, the extension of water mains was financed by the Water Department, and this year we started for the first time to make assessments based on the cost of a six inch main. That is virtually the same plan Mr. Saville outlined to you. What the Legislature had in mind in passing this law I do not know, probably they were following Milwaukee's plan; but I think it is a fair way to handle the situation. Our cost last year on a six inch main was $1.60 per foot and we are assessing 80 cents a foot against the property on each side of the street. Assessments are made for benefits, and while the law does not make any provision as to how corner lots shall be treated we are treating them the same as Milwaukee; on the short side of the lot where the main is laid, the full frontage is charged; on the long side we deduct one third of the sum of the two sides. Because of the fact that this is the first year we put this into effect the Water Department is going to finance the proposition in two year payments. After the main is constructed, by the way, we construct all our own water mains by city labor, we send out a thirty day notice that their assessments are now due and payable, and if not paid within thirty days, 6 per cent interest will be added, so that the first payment, if not paid in cash, will be entered on the tax roll the first year, and the second payment the second year. That is the way it is being handled in Kenosha.

James E. Gibson: The matter of assessments seems to be one of local conditions. There are so many different ways of reaching the same end. In our case at Charleston, the private water company was organized in 1876 and made the extensions on the order of the City Council. In 1917 the city purchased the plant placing it under the management of the Commissioners of Public Works. This Commission is organized under a state charter and is independent of the City Council. Immediately after the organization of the Commission we had requests for extensions of mains in this and that section, and upon our refusal we were met with this argument, "I helped float bonds with which to purchase the plant and I am paying interest on these bonds. Why should Mr. Smith on Broad Street have a water main and be able to obtain water in his house while my property in the north west section of the city

has to go without water?" The Commission adopted a general ruling that the policy of the Commission would be to lay mains in all streets in the city of Charleston, first on those streets that were built up and in which the revenue would warrant a reasonable return on a 6 inch pipe, and continue the laying of mains as fast as the other portions of the city built up and upon the same basis.

If a party owns property and wants to develop it in advance of the natural growth, we will extend out mains into this development laying not less than a 6-inch main. A regular contract is made and an estimate prepared as to the cost of making this extension and the land development party pays the amount of this estimate over to the Commission and at the same time signs a contract which provides that the Commission will return him each year an amount dependent upon the number of consumers that are connected on to this extension; these refunds to be made during a period of ten years. No interest is paid on the cost of the work and should the amount returned the development party at the end of ten years not equal the cost of the extension then all accounting ceases. If the cost of the extension is refunded to the party previous to the expiration of the ten years, then the contract is cancelled and all accounting ceases, the idea being to return the cost of the investment without interest to the land company. However, if the development does not pay within ten years it is considered a bad investment. During the past six years we have made twenty three such contracts, and in ten of these contracts one-half of the money has been returned to the development company within the first three years. The entire schedule is working out very nicely, and we have very little complaint and the question of extending mains to one party and not giving similar service to another has been entirely eliminated.

As to bond issues; the more I see of bond issues the less I like them, and I am beginning to be a strong advocate of the "Cash and Carry Plan." We had a discussion this morning about trade wastes, etc., and we are simply saddling posterity with the bill to pay at the end of 25, 30, 40 or 50 years. I think we should take care of our immediate troubles and let the future generations take care of their vast undertakings. They are going to have plenty to pay and my experience for the last twenty five years is that we are paying more and more every year, and I want to endorse what Mr. Chester has said, "What is good for the private company is doubly good for the municipality."

J. M. Diven: Mr. Gibson endorses Mr. Chester's statement, which is in effect that the affairs of a municipality should be conducted the same as a private company; but he is not entirely consistent, for he opposes bond issues to finance water works construction and advocates the "pay as you go" theory. Water companies must depend on bond sales or stock sales to finance all construction as under state commission regulations they are not allowed to charge water rates high enough to create a fund for extensions and improvements. Nor are they allowed, in any case that the speaker knows of, to assess abutting property for the cost of laying a main in front of it. They must raise capital as any business concern has to raise it. If they cannot sell stock or bonds they must use the money that the capital they have put in earns, earns at reasonable rates and according to most state commission regulations as a reasonable return on the investment. That means that their earnings are reinvested in the business by compulsion, as they must supply the demand for water and for extensions to supply water, must keep up with the growth of the city whether they get cash returns on their investment or not.

To the speaker it always seemed strange that municipal business should not be conducted exactly as private affairs are conducted. For a city water works the capital, raised the same as for a water company, except that there could be no sale of stock, must all come from bond sales.

THE COÖPERATIVE TREATMENT OF THE ELECTROLYSIS PROBLEM AT COUNCIL BLUFFS, IOWA, AND OMAHA, NEBRASKA[1]

By P. H. Patton[2]

It is common practice to speak of electrolysis when we mean "stray current electrolysis." We engineers should, however, remember that there is a second division of the subject; that is, local action produced by and known as "soil corrosion."

Your Association has given some consideration to this question from time to time for approximately thirty years. I find among the earliest literature references to a paper by Charles A. Stone and Howard C. Forbes in the New England Association's proceedings, 1894–1895, then among the latest a paper by E. R. Shepard[3] before your Illinois Section at Decatur, in March this year.

We have experienced trouble from stray current electrolysis in Omaha since 1892–1894, as illustrated by the photograph of cast iron, wrought iron and lead water and gas pipes made in 1894. Professor Father Joseph Rigge of Creighton University made a careful study and report of these conditions to the Omaha Board of Public Works at that time. (See figure 1.)

The telephone plant with which I have been associated during the above period also suffered from electrolytic destruction of some cable sheath.

Various more or less effective remedies were applied by the Water, the Gas, the Telephone, the Electric and the Telegraph Companies, as they placed underground cables. Each interest was looking out for No. 1 without much regard for his neighbor and at that time without much help from the Electric Railways. Later, when the Electric Railways consolidated and erected a central steam power

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Division Supervisor Plant Methods, Northwestern Bell Telephone Company, Omaha. Chairman Omaha and Council Bluffs Electrolysis Committee. Secretary Nebraska Joint Committee on Physical Relations between Electric Supply and Signal Lines.

[3] See Journal, July, 1923, page 603.

FIG. 1

SPECIMENS 1 AND 3. Taken up at 20th and Nicholas Streets, about 60 feet north of power house.

SPECIMENS 2 AND 5. Sections of same pipe, about 60 to 100 feet further north.

SPECIMENS 1, 2, 3 AND 5. Eight-inch water main.

SPECIMEN 4. One-inch gas service of iron.

SPECIMENS 6 AND 7. One-inch water service of lead.

plant on the Omaha side of the Missouri river within a few hundred feet of the Electric Light and Power Company's plant, a very unbalanced system of current drainage developed, because it was a very easy matter for the Electric Light Company and the Railway Company to increase their bond to the Railway negative bus and unload all the stray currents their cable sheaths might pick up.

The other underground structures did not center at Jones street and the river bank, and their problem was becoming increasingly difficult with the growth of the city.

This was the situation in 1915 when our attention was attracted to the valuable work of the United States Bureau of Standards, which had begun a serious study of electrolysis about 1913 and had already published two or three bulletins on the subject. Early in 1916 the Omaha Technical Club arranged with the Bureau of Standards to have their Mr. Burton McCollum speak before the club on the activities of the Bureau with specific reference to electrolysis surveys and mitigation. This served to bring the matter to a focus and the Metropolitan Water District, the Omaha and Council Bluffs Street Railway Company, the Omaha Gas Company and the Nebraska Telephone Company joined in a request that the Bureau send a representative to supervise a survey. Later the Council Bluffs Water Department, the Western Union Telegraph Company, the Postal Telegraph Company, the Omaha Electric Light and Power Company, with the Citizen's Gas and Electric Company of Council Bluffs, assisted to a limited extent in the survey work, done under the auspices of the Omaha and Council Bluffs Electrolysis Survey Committee.

The Bureau's formal report was submitted in January, 1917, and it included a recommendation that a permanent electrolysis committee be formed to carry out the other features of the Bureau's report. I am quoting this Committee's recommendation in full, since it really is the Constitution and By Laws of the Omaha and Council Bluffs Electrolysis Committee:

> In order to prevent a recurrence of the present objectionable system of competitive drainage and to provide for regular and systematic measurements relative to electrolysis conditions, it is recommended that a permanent electrolysis committee be organized consisting of a least one member from each of the utility companies concerned; the duty of which committee should be to establish and maintain unified, non-competitive drainage on the several underground systems and to see that this drainage is limited to the smallest practicable amount. The committee should also make periodic measurements and

keep generally informed regarding electrolysis conditions in the Cities of Omaha and Council Bluffs. It is suggested that, as far as practicable, the members of the committee be technical men, and that they be given the power to act collectively, thus reducing to a minimum the necessity of referring back to higher authorities minor questions which may come up from time to time.

Mr. George T. Prince, then Chief Engineer of the Omaha Metropolitan Water District and well known to most of you water men, served as Chairman of the Committee the first year or two. The Electrical Engineers of the Railway Company have performed the duties of Secretary and Treasurer continuously and the speaker has acted as Chairman since Mr. Prince resumed private practice.

After organization, the Committee carried out the principal recommendations of the Bureau as follows:

1. The voltage gradients in the negative return circuits were reduced by these methods:

A. The placing of some additional insulated negative return feeders.

B. The establishment of sections of negative trolley wires and feeders. (The so-called "three wire system.")

C. The provision of a power substation (automatic) in Council Bluffs, where approximately half of the current had been returning by irregular routes.

D. Drainage was reduced and controlled by rheostats.

2. The Committee agreed upon a prorate of its annual expenses to be based upon the approximate mileage of track or trench in their sub-surface systems. This expense now averages $1500 per year.

3. The Committee arranged to maintain 40 potential taps to the rails, renting several miles of wires from the Telephone Companies for the purpose of bringing all taps to a central point where continuous use is made of these taps, readings being made on recording meters. This has been helpful in securing a high standard of rail joint bonding.

4. The Committee makes an annual coöperative survey of the potential differences between the various underground structures, using in rotation about 20 per cent of the stations established in the original survey and some additional stations where extensions have been built.

In order to maintain an active interest and prevent the matter becoming merely perfunctory, we have found it desirable to hold monthly luncheon meetings on regularly predetermined dates, with special meetings as required. This system has resulted in twenty-six meetings during the last twenty-four months. This monthly contact takes care of current routine matters and bills and also results in a general exchange of information as to proposed system changes and extensions.

We have succeeded in reaching equitable and agreeable conclusions in all matters so far handled, but we, as a committee, have

avoided any references to or discussion of the legal aspects of our cases.

The apparent success which attended the efforts of the Committee during the first two years of its existence was so marked that the interests which were reluctant to join at first came in whole-heartedly, and the work now has the unanimous support of the utilities maintaining metallic underground public service structures in Omaha and Council Bluffs. The roster of membership as shown on our letterheads and the present prorate of expense is:

Northwestern Bell Telephone Company	15.36
Nebraska Power Company	13.44
Metropolitan Utilities District:	
Includes Omaha Water Plant	16.32
Omaha Ice Plant	
Omaha Gas Plant	16.32
Western Union Telegraph and Cable Co.	3.00
Postal Telegraph Cable Co. of Nebraska	1.00
Omaha and Council Bluffs Street Ry. Co	23.04
Council Bluffs Independent Telephone Co.	3.84
Citizen's Gas and Electric Company	3.84
Council Bluffs City Water Works	3.84

The Omaha and Council Bluffs investigation was not published as a Bulletin by the Bureau of Standards partially because of lack of funds. Each participating utility was, however, furnished a complete set of reports and I have here a copy for your inspection. The more unusual features of our situation have been referred to in your Association several times, the most recent reference being Mr. Sam L. Etnyre's discussion of E. R. Shepard's article[3] in your JOURNAL.

The following magazine articles also were based on some features of the Omaha and Council Bluffs Electrolysis Committee's work:

"Line Drops and Rail Potentials Reduced by Three-Wire System in Omaha." E. H. Hagensick, Elec. Ry. Journal, November 10, 1917.

"Sectionalization of Overhead Wire for Three-Wire Operation." E. R. Shepard, Elec. Ry. Journal, December 8, 1917.

"The Automatic Substation in Electrolysis Mitigation." E. R. Shepard, Electric Railway Journal, April 30, 1921.

Mr. Corcoran's paper,[4] on the relation of water works to fire insurance rates, before this meeting, brings to mind the fact that

[4] This Journal, page 79.

the National Board of Fire Underwriters in the preparation of their Report No. 63 on Omaha and No. 228 on Council Bluffs took quite an interest in our Committee activity and endorsed the results that we have attained in the above reports.

In addition to the above articles, any of you who are interested in a detailed study of the technical aspects of electrolysis may obtain from your National Association a copy of the 1921 Report of the American Committee on Electrolysis. This report includes quite a complete bibliography of the subject which should be helpful in your further studies.

In addition to the photograph previously mentioned, I have here a gas service destroyed by stray current electrolysis and a piece of lead telephone cable sheath showing marked electrolytic effects. This telephone cable was in service from about 1893 until about 1916. We believe the damage was done about 1894–1895 but the remedial measures applied then stopped further losses. The lead sheath was still sufficient to prevent the entrance of moisture, consequently the wires in the cable were serviceable while undisturbed. However, upon removal, we found a considerable loss in weight of lead salvage.

While stray current electrolysis is largely a result of ground-rail return street railway systems, it is not safe to assume that the absence of street railway tracks gives immunity. Any grounded direct current electrical system may produce destructive electrolysis. We know of one town in Nebraska where a direct current three wire 220 volt lighting plant operated grounded and ruined the underground cable sheath of the local telephone plant.

SOIL CORROSION

This subject is an important one especially in cities with considerable areas of "made ground" or with cuts and fills which intermingled the various soils.

Our Omaha and Council Bluffs Committee has been coöperating during the last two years with the American Committee and the Bureau in their soil corrosion study. We have buried at Omaha 80 pipe samples in Knox silt loam and another 80 in Wabash silt loam. There are six sets in each soil and during the next six to ten years a set will be unearthed from time to time, carefully tested and weighed. Similar work is under way in more than forty places in the United States.

I have here a sample of corroded $\frac{3}{8}$-inch gas-pipe as proof of the fact that local action or self-corrosion may take place inside modern concrete buildings. To reduce dead weight, cinders are sometimes substituted for gravel, or crushed rock in concrete fills. In an Omaha building where such a fill had been used between the ceiling and roof slabs, a gas leak developed and was traced to this pipe. This particular piece does not show a puncture, but several deep pits.

I believe Mr. Knouse, when inviting me to present these remarks to you, had in mind that I emphasize the coöperative feature of our work the last six years. I feel that our Committee exemplifies the success of the four "C's", a slogan promulgated throughout the Bell System by Mr. E. K. Hall, Vice-President of the American Telephone and Telegraph Company. The four "C's" are: Contact, Conference, Confidence, Coöperation.

Another member of our Committee has said that we have succeeded in substituting coöperation for competition, referring to our former disastrous competitive draining return system. Still another member says we are succeeding by substituting Mitigation for Litigation in approaching the problem.

THE RELATION OF WATERWORKS TO FIRE INSURANCE RATES[1]

By Harry J. Corcoran[2]

One of the two principal functions of a water supply system is to furnish water for the extinguishing of fires. Every superintendent is anxious to furnish the best service possible and to have his community receive maximum benefit in fire insurance rating. The methods used by insurance organizations in determining the value of a system must therefore be of considerable interest to this organization. It is hoped that this paper will present information which will be of use in operating and planning additions to existing systems.

Water is applied to fires through both public and privately owned equipment and different methods are used to measure the suitability of the service for each type. In this territory the National Board of Fire Underwriters Standard Grading Schedule is used to grade the system in connection with the public fire department. The rules of the National Board of Fire Underwriters and the Central Actuarial Bureau are used in grading the value of service for supply to privately owned automatic sprinkler equipments.

A general consideration of the Standard Grading Schedule is necessary to understand properly the relative part the water supply bears to the complete fire fighting facilities. The schedule is based upon the plan of assigning to the various features of fire defense found in cities, points of deficiency dependng upon the variance from standards formulated from a study of conditions existing in approximately 500 cities. The maximum total charge possible is 5000 points which represents no protection against fire. The maximum charge which could be made for lack of a water system is 1700 points; this is the greatest value assigned to any single department, the Fire Department being next with a maximum charge of 1500 points. Cities are divided into ten different groups called classes;

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Chief Engineer, Iowa Insurance Service Bureau, Des Moines, Iowa.

no protection is called Class 10, and as protection is improved the class number is reduced, the differential being 500 points. This makes the water supply equivalent to 3.4 classes. In compiling insurance rates, all charges for hazards in buildings are added to a base rate; this base rate is determined by the class of public protection and the better the protection the lower the base rate.

A water system is examined on three points: viz., adequacy reliability and pressures; thirty-two items are considered independently and the sum of the individual charges determines the relative class of the system. A gravity system in which water is delivered direct from the source to the city is the ideal for fire protection, but a properly safeguarded pumping system is thoroughly reliable. In general, such duplication of parts of the waterworks is required that with those parts out of service, which may reasonably be expected to be inoperative, the system will still be able to furnish required fire flow. The introduction of storage, either elevated or for suction supply, offsets the need of duplication in those parts of the system through which storage has passed; storage sufficient for ten hours fire flow and five days consumption is assumed as offsetting need of duplication. In estimating required fire flow, an allowance is made for probable loss from broken connections incident to a large fire, experience frequently being that one-third of the water delivered to hydrants never reaches the fire.

The quantity required is determined by formula based on population, the gallons per minute being $1020\sqrt{P}\,(1-0.01\sqrt{P})$, P being the population in thousands; this is the quantity estimated as necessary to control a serious block fire in the mercantile district or two simultaneous fires of considerable magnitude. Smaller quantities are required for districts outside the principal mercantile district. This exceeds the quantity recommended by Kuichling, Freeman and other eminent engineers, probably due to allowance for waste and advance in equipment for handling fire streams. In towns and cities larger than 2500 population supply should be sufficient to maintain fire flow for ten hours in addition to domestic consumption. Measurement is made on the ability of the system to deliver fire flow at any pressure down to 20 pounds, this being the minimum pressure at which supply is of value for fire streams. The ability to deliver water at pressures sufficient for direct hydrant streams is credited to offset lack of fire department pumping engine capacity; for direct hydrant streams 75 pounds residual pressure

at hydrant during flow is necessary for 4-story buildings, 60 pounds is satisfactory for 3-story buildings and 50 pounds for 2-story buildings and in residence districts.

Under adquacy the normal ability of supply works to maintain domestic consumption demand and fire flow is considered. This includes impounding reservoirs, collection galleries or wells, filters, intakes, suction lines, pumps, power supply, air compressors, force or supply mains and storage. Flow tests are made at various locations to determine the capacity of mains in the distribution system. Variation of supply from wells or runoff at different seasons of the year is also considered. Adequacy is deemed of first importance.

In arriving at the reliability of the system, each step or operation necessary in delivering water from the source to hydrants is treated separately. All pumps should be duplicated and a heavy charge is made if maximum capacity of the plant cannot be continued with the largest unit out of service; absolute safety requires sufficient reserve to maintain maximum operation with two pumps out of service. Where water passes through two or more sets of pumps in series, charges for each set are totaled, with allowance for storage. The importance of large clear water storage in connection with filter plants is obvious. Duplication of boilers, electric generators, oil engines or other power units is graded in the same manner as pumps. Steam engines and motors are considered an integral part of pumps.

The condition and arrangement of pumps and power equipment is judged with a view to efficient operation and ease of repairs. The following forms and combinations of plant equipment, if of proper design and well installed, are assumed as approximately equal, advantage if any being in the order given:

(a) Centrifugal or reciprocating pumps driven by steam engines.

(b) Centrifugal or recriprocating pumps driven by electric motor.

(c) Pumps operated by water power.

(d) Centrifugal or reciprocating pumps operated by internal combustion engines suitable for the service. Service record in the plant under consideration and in similar plants is studied in arriving at an opinion.

Sufficient fuel should be kept on hand for five days consumption. Steam lines, oil piping, electric transmission lines, and boiler feed lines should be so arranged that the renewal of a valve, transformer, oil or boiler feed pump, will not prevent maintaining full supply of water for two days.

Pumping stations and power plants should be of fire-resistive construction or equipped with an automatic sprinkler system. First aid fire fighting equipment and connections for the fire department are advantageous. The building should be protected from exposing structures. Hazards such as heat, electric wiring and control devices, oils and oily waste, and chemicals must be safeguarded.

Reliability of supply mains is considered both upon the possibility of a failure and the effect of a failure. Duplication is required to such a point that a single failure will not reduce the amount of water delivered nor seriously affect the pressure. All pipe lines necessary to continued operation are included under this heading. Concrete or masonry aqueducts substantially built are assumed dependable enough not to require duplication. A charge is added where the most serious failure would occur in a long line. Cast-iron, wrought-iron and wood-stave pipes have been found satisfactory in various places when well installed. Mains should not endanger each other, and their failure at stream crossings, at railroad crossings, in filled ground, and at other points where physical conditions are unsatisfactory should be guarded against; ease of making repairs is taken into consideration.

In connection with supply mains arteries and secondary feeders extending throughout the system are necessary. These feeders shall be of sufficient size to deliver fire flow necessary for the district, shall be frequently spaced and looped; practical dependence of large sections of a city on single mains constitutes a deficiency. Arterial arrangement is divided into fair, poor and very poor. Mains in the arterial system shall be safely installed, the same as supply mains, and shall be so gated that a single failure will not put more than $\frac{1}{4}$ mile of pipe out of service.

Six-inch is the minimum size pipe which is suited for hydrant supply, and it should be well cross-connected. Experience with 4-inch pipe is such that it is considered a detriment to the system and a charge is accordingly made; the same is true of dead-end 4 and 6-inch pipe. The practice of installing 4-inch pipe cannot be too strongly condemned. During several hundred tests which the speaker has made during recent years, in no case could the hydrant be used to full advantage where connected to 4-inch pipe. The proper sizes for minor distributing pipes depends upon the character of the district served, but they should be well cross-connected and gridironed. Pipe of course should be of good quality,

suited to pressures and well laid. Electrolytic action must be guarded against.

Gate valves are very necessary to localize the effect of a break. The spacing in high value districts should not exceed 600 feet, and in other districts 900 feet. Inspection of all valves yearly and important valves on feeder mains more frequently will insure good condition and will prevent a valve remaining accidentally closed. Records of all valve operations aid proper inspection. A charge is made for lack of inspection or poor condition of valves.

Hydrants should be sufficient in number to supply the required fire flow without the use of long lines of hose. The linear spacing is subject to much variation because of different sized blocks. In the grading schedule, the distribution is worked out on the area served by each hydrant. A table has been made up which gives the standard area to be served per hydrant on the basis of different fire flows required, and for both direct hydrant streams and engine streams. The table is too long to give here but an idea of it may be shown. With direct hydrant streams and 3000 gallons per minute required, one hydrant should be installed for each 70,000 square feet; with engine streams and the same quantity one hydrant for each 100,000 square feet is satisfactory. As the quantity is increased the spacing must be closer. Hydrants should be able to deliver 600 gallons per minute with a loss of not more than $2\frac{1}{2}$ pounds in the hydrant and a total loss of not more than 5 pounds between the street main and the outlet. Two $2\frac{1}{2}$-inch outlets and a large suction connection, where pumping engines are used, are necessary. Street connections and barrel should be 6-inch diameter, with a gate valve on the connection. Hydrants which will remain closed when the barrel is broken off are a necessity with present traffic conditions.

The proper method of setting hydrants varies with the location. Good drainage, solid support for the barrel, ease of repairs and good outlet clearance above the ground are essential. Frequent inspections are needed to maintain hydrants in the best condition. Hydrants are not built for frequent service and use by others than the fire department or inspector should be discouraged, and if necessary special hydrants installed for street sprinklers.

Good records would seem to be a most necessary feature of any water system; to be of value they should include plans of piping at pumping stations and in the distribution system, records of operation, repairs and performance of each part of the water-works. The lack of records, especially in the smaller communities, is astounding.

Use of public water supplies through privately installed automatic sprinkler systems is on the increase. This is not surprising since these systems provide the most effective fire protection yet developed, and give a property so equipped a greatly reduced fire insurance rate. Water superintendents should actively encourage installation of them as they are directly benefitted. Reports on 28,560 fires in buildings so protected show that 20,234 or 84 per cent were extinguished with ten or less sprinkler heads opening, or about 300 gallons per minute maximum. Only about five per cent required more than 1000 gallons per minute. While records are not available there is no question that the same number of fires in similar buildings not so protected would have required many times the same quantity of water, and it costs money to pump water. It is not conceivable for a spreading fire to occur in a district well filled with automatic sprinkler equipments, and the chance of an outside fire entering a sprinklered building is practically eliminated. It seems plain then that the greatest dread of the superintendent, namely a conflagration, would be very remote if buildings were generally protected in this manner. The water used in water curtains from outside sprinklers is large but in few cases would it exceed the quantity used in fire streams to provide the same degree of protection.

The value of a sprinkler system is entirely dependent upon a reliable and adequate water supply. No equipment is standard unless supply can be obtained from two independent sources, generally a tank or pumps installed by the building owner and the public water system. The private supply works are a part of the equipment and are handled directly with the property owner. A public supply, to be satisfactory as the primary source, must be able to maintain 12 pounds pressure on the top line of sprinklers while 500 gallons per minute are flowing from the nearest street hydrant. If the public supply is to be used as the primary source the pipe connection must be large enough to pass sufficient water for all heads on the largest floor or area. No pipe smaller than 6-inch is of value and in many cases larger pipe is needed. The possibility of pollution to domestic supply is recognized and double check valves of special design are not considered detrimental. Many superintendents fear misuse of such connections; friendly coöperation with owners will generally prevent this, but special meters can be purchased suitable for the service. The charges made for

such a connection vary greatly. Many cities show a tendency toward basing charges upon the insurance benefit the property derives from this service and this is not considered just. The owner simply does the work which the fire department would otherwise perform, and in a much more effective manner, and should not be penalized for it. Charges which cover installation, maintenance and carrying charges are warranted and there is seldom objection to them.

In conclusion, any effort which will help to check and reduce the senseless fire waste in this country is justified. The saving of a few dollars by omitting needed repairs, an extra pump or added supply, by laying smaller pipe than required, or failing to keep all parts of the system in good condition may result in a disaster in your community, far outweighing the saving. Make your efforts toward providing reliable fire protection commensurate with the importance it deserves and your city will enjoy more freedom from fire losses, which means lower insurance rates.

USE OF PORTABLE AIR COMPRESSOR ON WATER WORKS DISTRIBUTION SYSTEM[1]

By F. C. Amsbary[2]

I confess to being somewhat embarrassed in appearing before you this morning for the reason that I am so poorly equipped to talk upon the subject assigned to me. Mr. Gwinn sometime ago wrote asking me to write on some subject. I was somewhat at a loss to find a subject that I thought might be interesting, but as we had placed an order for a portable air compressor to be used in our distribution system in various ways, I sent that subject in to him, believing that I would have sufficient time to gather some reliable data, but they were slow in delivering this machine and I only had it in actual use about a week before I left Champaign for this convention. In that time we finished a few jobs and I can give you the figures on them.

Our plant is a rather small one having about 95 miles in the distribution system and 7000 active services. We have in our city perhaps 30 miles of concrete pavement and brick laid on concrete, and in case of leaks and extension connections, as you all know, it is frequently necessary to go through the concrete. Our plant is not large enough to justify the expenditure of a sum sufficient to buy an air compressor for our own exclusive use, so we talked with some of the contractors there and were assured that they would give that machine considerable use by rental, so we went into the proposition. We bought an air compressor mounted on a Ford truck so arranged that by throwing a lever it would engage the air compressor. This outfit would be a considerable advantage over the kind of a compressor we would have to haul around from job to job. I think that is going to work out all right. We took one job from a contractor who was putting in an ornamental lighting system. I had him keep a record of just what it was costing him to take out

[1] Presented before the Superintendent's Session, Detroit Convention, May 25, 1923.

[2] Manager, Water Company, Champaign, Ill.

the curb and gutter along the street in the business district where he was going to lay his conduits, and in this one case he had a stretch of 121 feet and it cost him 22 cents a lineal foot to remove the curb and gutter. On the opposite side of the street we took out exactly the same amount of concrete and we did it for $9\frac{1}{2}$ cents per lineal foot. Charging him at this rate we fixed this price after careful figuring, taking into account interest on invested capital, depreciation and repairs. We had a case where we took out for our own use on our own work a stretch of 21 feet long by 2 feet wide of very hard concrete, which we did in twenty minutes, while on the best record we had on that sort of work it would take two men two hours each. As I said in the beginning, I am sorry that I have not been able to give you more data, but I am quite certain it is going to pay us to have that machine and the revenue that we will receive from contractors will, I think, in time make it a very good investment.

The cost of this machine, the compressor and tools, was $1087.31; the truck cost $557.88. The expense to bring it from the place where it was purchased to our town was $44.50 making a total, investment of $1723.

I might say that there are other uses to which we intend to put this machine. For instance, we have bought a pneumatic spade, and I think we will get splendid use from the spade; it will take the place of picks. It is worked on the same principle as the concrete breaking device, it just spades up the earth where it is very hard and turns it over, and then it is shovelled out; it simply takes the place of a pick but does the work much more rapidly.

SAFEGUARDING HOT WATER INSTALLATIONS[1]

By Chetwood Smith[2]

A better title would perhaps have been the necessity of safeguarding hot water installations.

With the exception of the first range boiler explosion, all the photographs appearing herein were either taken by or for the Stack Heater Company. The tests shown were made on actual installations and in no sense could be called laboratory tests.

The interesting feature of the first explosion shown in figure 1[3] is that the entire corner of the house was blown out and as far as our records go we know of no other explosion in which this took place.

The tubes of gas water heater used in these tests were of copper of five sixteenths outside diameter, 18 gauge, which gives a ration of heating surface to area of 20 to 1.

A $\frac{3}{4}$ inch coil gas water heater which has a ratio of only 6 to 1 heating surface to area would of course require a longer time for explosion, but would produce exactly the same results.

The most interesting feature of the explosion shown in figure 2 is the resultant location of the boiler stuck in the ceiling between the top floor and the roof and what is most interesting about this special photograph is that although it is copyrighted, a competitor borrowed if for his advertising without permission. Perhaps he made a mistake.

Boiler explosions do not care whether they have shingle houses, business blocks or concrete homes for their work and they always proceed in the same thorough manner. In an explosion in a business block the relief valve was afterwards found. This was tested by the State Inspector in our factory and failed to operate until the pressure was raised to 640 pounds.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] President and General Manager, The Stack Heater Company, Boston, Mass.

[3] All photographs copyrighted by Stack Heater Company.

In another explosion the houses were too near together to get a good photograph of the outside of the house. The interesting feature of this explosion is that the boiler must have rocketed two hundred yards above the house as it was exactly 112 yards down the street when it landed. When the super heated steam in this boiler had used up its energy a partial vacuum must have been formed which collapsed the sides of the boiler.

FIG. 1

A wallet was on the kitchen table within 5 feet of the boiler in a Watertown explosion. All the papers and bills were taken out and forced against the lathes on a side wall where they stuck. The wallet was left on the table. A bird cage with a canary in it was left hanging in the window. All the seeds and water were blown out, but the bird was unharmed.

In the Boston University explosion, 1200 students were close to this boiler 15 minutes before the explosion. The boiler must have split its entire length and traveled as a vertical plane before it struck a brick wall 40 feet distant, as the entire shell of the boiler bore the

imprints of the bricks. The market price of the relief valve used to safeguard 1200 students was eighty five cents.

Fig. 2

The energy developed by such explosions is indicated in the figures tabulated in table 1. These figures are not the result of actual tests made by us, but were compiled by Professor Miller of the Boston Polytechnic Institute.

FIG. 3

A safe relief valve should have the water constantly passing through it to prove that the boiler pressure has access to the valve. It should preferably be of a diaphragm type.

These are requirements as laid out by the Boiler Code Committee of the American Society of Mechanical Engineers. There is no valve at present on the market which meets all these require-

TABLE 1

Energy developed by explosion of 30 gallon tank of hot water under varying temperatures and pressures

PRESSURE			TEMPERATURE AT BOILING	WEIGHT OF CUBIC FOOT WATER	WEIGHT IN 30 GALLONS	PER CENT FLASHING INTO STEAM	WEIGHT FLASHING INTO STEAM	VOLUME OF STEAM	FOOT POUNDS ENERGY LET LOOSE
Absolute	Gage	Feet of water							
14.7	0		212.0						
24.7	10	23.1	239.5	59.06	237	2.81	6.66	178	479,800
34.7	20	46.2	259.0	58.52	235	4.75	11.1	298	914,100
44.7	30	69.2	274.0	58.20	233	6.21	14.5	378	1,305,000
54.7	40	92.3	286.6	57.59	231	7.41	16.4	440	1,689,300
64.7	50	115.4	297.7	57.26	230	8.46	19.5	521	2,021,900
74.7	60	138.4	307.4	56.93	228	9.36	21.4	570	2,341,200
84.7	70	161.7	316.0	56.66	227	10.1	22.9	614	2,642,000
94.7	80	184.6	324.0	56.36	226	10.9	24.6	660	2,900,000
104.7	90	207.7	331.2	56.23	225	11.5	26.1	700	3,138,400

A comparison with powder may be interesting:

One lb. black powder gives..... 960,000 ft. lbs.
One lb. smokeless powder gives.....1,260,000 ft. lbs.
One lb. nitroglycerine gives.....2,000,000 ft. lbs.

ments, but there will be very soon as one was yesterday submitted to and approved by the Chief Inspector for the State of Michigan.

THE EFFECT OF INDUSTRIAL USES OF WATER ON TOTAL CONSUMPTION[1]

By J. Walter Ackerman[2]

The above title would indicate a comprehensive research, but the reverse is the actual fact in this case, because only enough is intended to be given to induce others who are more capable to discuss the subject from any standpoint that they desire.

The writer took charge of the water works in Watertown in June, 1920, and immediately started the installation of meters, and later had a Pitometer survey made. This brought down the consumption from an abnormal one to a reasonably normal rate per capita. It will be noted from figure 1 that the consumption rate began again to climb up. This reaction was to be expected to a certain extent but as it continued for a longer period than anticipated, an analysis was made of the different classes of use to see if some reason could not be found for the rising rate per capita.

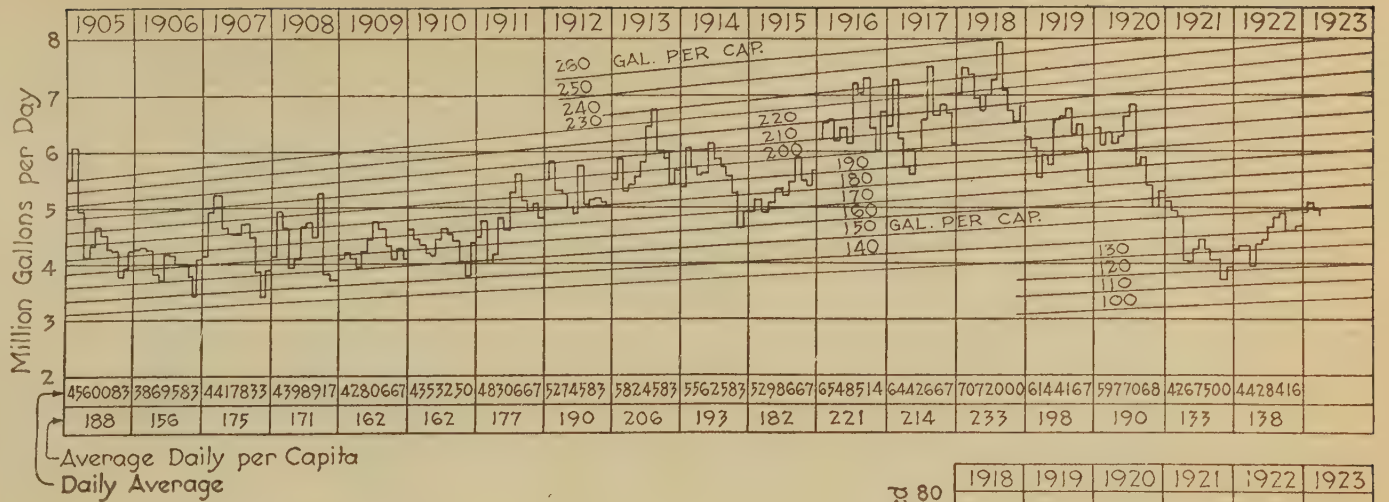
This consisted in tabulating the metered consumers for the different classes of use that were not domestic. The analysis of what is covered under the title of industrial, actually includes not only all of the industrial use, such as factories, railroads, etc., but also the large consumption of business blocks and office buildings.

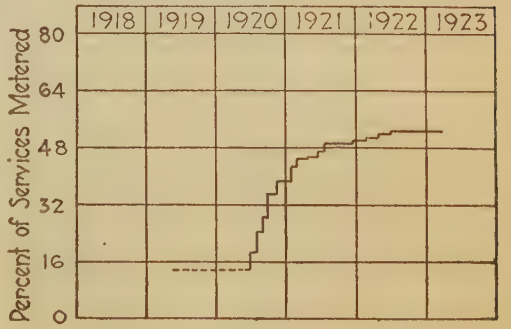
It is later seen from figure 2 that the domestic use, after dropping from the high rates of 1918 and 1919, has actually remained nearly stationary after the installation of the meters, which covers something over 50 per cent of the total number of services in the city.

The conclusion to be arrived at in this case, if a conclusion may be deduced from this small analysis, is that increasing per capita rates should be investigated from a somewhat similar angle, in order to determine whether or not increasing activities in the city do not adequately explain the increasing per capita rate. Instead of looking immediately for other reasons, it is well to examine the industrial uses first.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] City Manager, Watertown, N. Y.





Consumption Chart

Watertown, New York

Fig. 1

In connection with this it might well be pointed out that the financial side of the water works might be seriously handicapped by a large rise in industrial use of water, which usually is sold at the lowest rate of all. In some cases unfortunately this rate does

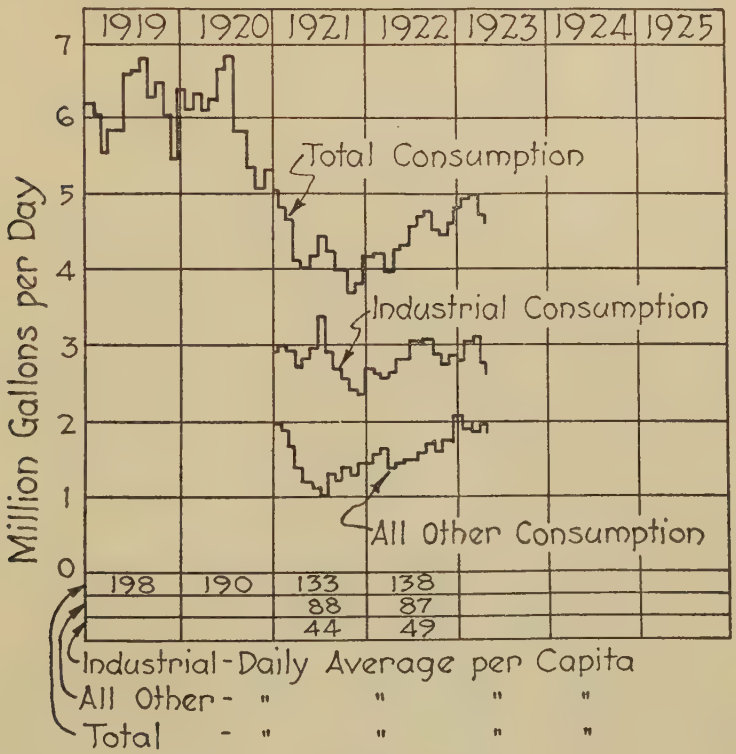


Fig. 2

not represent the actual cost of the water supplied. Consequently a water works might find itself very seriously handicapped, if industrial consumption mounted to a high figure in proportion to that of other uses.

THE PURIFICATION OF COLORED WATER AT WILMINGTON, N. C.[1]

By George D. Norcom[2]

INTRODUCTORY

The subject to be considered in this thesis is the purification of the water of the Cape Fear River at Wilmington, N. C. This southern seaport city is situated at the junction of the two main branches of the Cape Fear River at a point about thirty miles from the sea. It has a population of some 35,000 persons. The city is completely sewered, but has no system of sewage disposal. Like many other old cities in this country, Wilmington is not located favorably from the point of view of obtaining a potable water supply of natural purity. This section of the coastal plan is characterized by alternate layers of sand, gravel and limestone with some deposits of mud and clay. Practically all of the sand is water bearing but the water is salt below a depth of 350 to 400 feet. From 60 to 200 feet below the surface the Peedee sand yields a clear water of high temporary hardness. The amount of this water available is conjectural and it is poorly protected against pollution. A number of small private wells tap this source. The possibilities of securing a city water supply from underground sources have been very thoroughly studied and the consensus of expert opinion has been emphatically against such a project (1), (2), (3). In view of these facts Wilmington was forced to turn to the river to secure a public water supply.

THE CAPE FEAR RIVER

At Wilmington, the Cape Fear River divides into the Northeast and Northwest branches. The Northeast Branch has a flat grade and drains a vast area of swamp land so that the run off of the stream is very largely composed of swamp water. This water is charac-

[1] Abstract of thesis presented to Rutgers College in partial fulfillment of requirements for degree of Sanitary Engineer.

[2] Health Department, Wilmington, N. C.

terized by a high color the result of the action of soft water on the organic matter of the swamp. This water is practically free from turbidity but has an average color of 150 (Platinum-Cobalt Scale). The Northwest Branch drains an area which is more hilly and rolling and is largely under cultivation. While the Northwest Branch has some highly colored tributaries, its water is normally turbid and has a color less than a hundred. Where the two branches come together at Wilmington a distinct line of demarkation is visible on the ebb tide. The flow of the Northwest Branch is several times greater than that of the Northeast Branch as will be seen from the following table taken from a report of the North Carolina Geological and Economic Survey (4).

Daily discharge of drainage areas above Wilmington (unit discharge 1.17 sec. feet per square mile)

STREAM	DRAINAGE AREA	AVERAGE ANNUAL DISCHARGE PER DAY
	square miles	*gallons*
Northeast Cape Fear	1570	1,186,000,000
Northwest Cape Fear	7005	5,295,000,000

There is a tidal change in the river four times each twenty-four hours with a rise and fall of about three feet.

SOURCE OF THE WATER SUPPLY

The present intake is located on the east side of the Northeast Branch above the city and about one mile from the junction of the two branches. (See figure 1.) The quality of the raw water is subject to frequent changes, the factors causing the changes being chiefly: (*a*) variation in the tides; (*b*) relative amounts of rainfall on the watersheds of the two branches of the river which affect their stages; and (*c*) the amount of sewage from the city which reaches the intake. The third factor is influenced by the first two, since the discharge of sewage per twenty-four hours is fairly constant. Normally, the water reaching the plant at low tide is the highly colored Northeast Branch water, while at high tide it frequently contains a large proportion of the turbid Northwest Branch water. During the ebb and flow of the tide varying mixtures of the two are encountered in which either type may predominate. For this reason, the raw water at Wilmington is one of the most difficult to purify which

may be found in the United States. These conditions are sometimes complicated by sea water reaching the intake.

The sewage from the main part of the city is discharged at various points along the water front. The sewage from a large part of the eastern section of the city formerly discharged into Smith's Creek, a small stream, which enters the Northeast Branch at a point about 1500 feet above the water intake. This sewage is now collected by an interceptor and pumped to the main river which it enters about one-half mile below the intake. However, great difficulty is experienced in operating these pumps and at frequent intervals the sewage

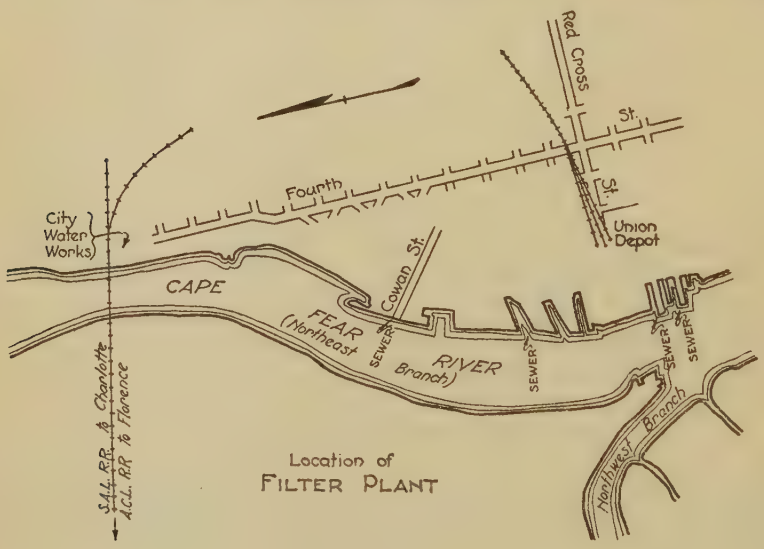


Fig. 1

is by-passed directly into the creek, ultimately reaching the intake on the ebb tide. A study of the most authentic data on the subject indicates that the tidal currents attain a maximum velocity of about one mile per hour and that water passing the intake on the flood tide must have come from at least three miles below. While the sewage is certainly subject to very great dilution, it is clear from a study of the analytical data that the raw water is at times highly polluted. It is to be borne in mind that this pollution is very fresh and therefore much more virulent, and that the bacterial evidence of pollution in such a stream has a much greater significance than it has in a stream

which has a greater period for self purification. In the light of recent advances in the art of water purification, it appears that the pollution of the raw water is in excess of standards for the loading of filtration plants. In 1914 the International Joint Commission fixed a standard for raw waters which provided, in substance, that the average load upon any water filtration plant should be such that the raw water delivered to it should not contain more than 500 B. coli per 100 cc. The reasonableness of this standard was later confirmed by Streeter in his studies of filter plant loading (5).

THE PURIFICATION PLANT

Historical

The first city water supply for Wilmington was furnished by the Clarendon Water Company which established a pumping station on the site of the present purification plant in 1881. At this time no attempt was made to purify the water. The unsightly appearance of the water and the prevalence of typhoid fever led to the establishment of a filtration plant in 1906. The preliminary studies in connection with adoption of filtration were made by George C. Whipple of Hazen, Whipple and Fuller (6). Briefly, he recommended the process known as mechanical filtration using alum as a coagulant. The first plant was built by the Pittsburgh Filter Co. and consisted of a sedimentation basin of 360,000 gallons capacity, four filters of 500,000 gallons each, a clear well of 160,000 gallons capacity and the accessory pumps, chemical tanks, etc. By referring to figure 2 the relative position of these first units may be readily seen; the basin is marked no. 2 and the filters 1, 2, 3, 4. This plant was operated by the engineer of the pumping station and while no operating data are available we may judge that results were not entirely satisfactory, since in 1911 the City again called Mr. Whipple. In a report (7) dated December 7, 1911, Mr. Whipple showed that the plant could be successfuly operated and recommended that a trained man be put in charge of the filters. In 1912, this recommendation was carried out.

As the consumption of water increased it became necessary to enlarge the plant. The first addition was made in 1911 under the supervision of Hazelhurst and Anderson, Consulting Engineers. This addition consisted of a new basin of 360,000 gallons capacity (no. 3 on figure 2) and filters installed by the American Water

Softeners Co. (nos. 5, 6, 7, and 8). The proposed plan of operation called for the two basins to be used in parallel, each being

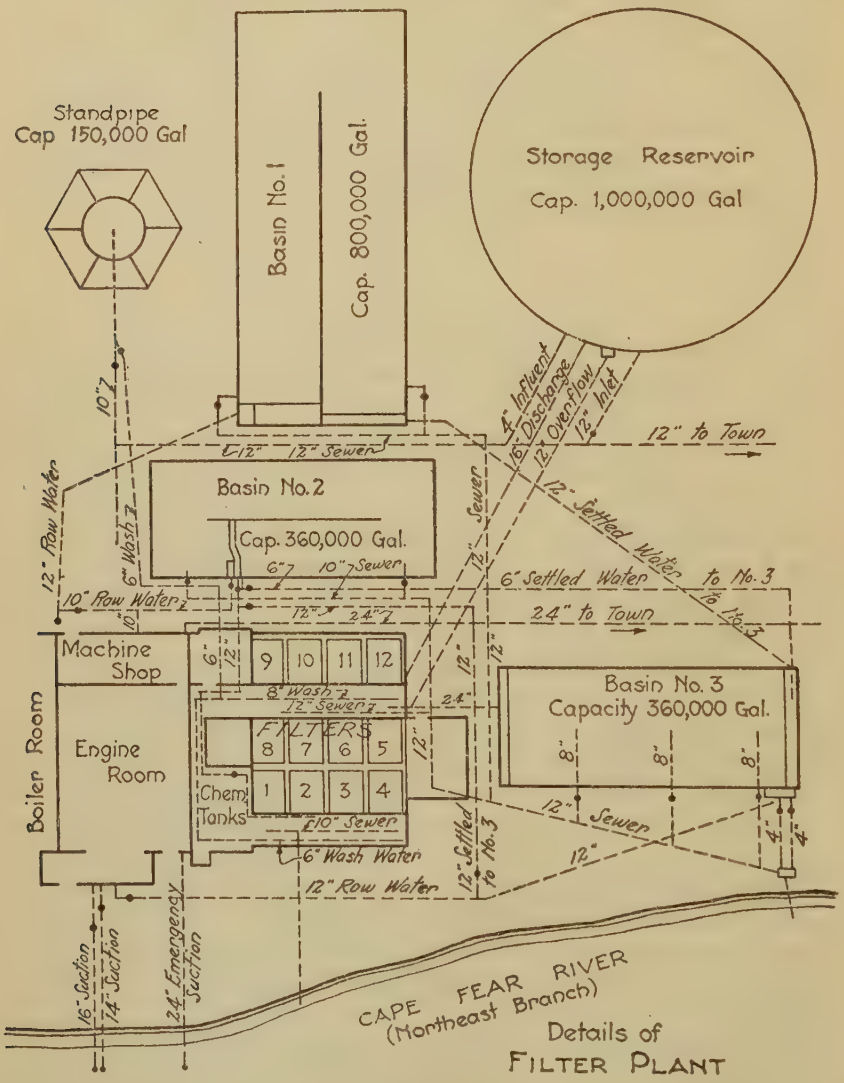


Fig. 2

supplied by a separate raw water pump. This scheme did not work successfully for several reasons; (*a*) chemicals had to be applied to

two points from one set of dosing apparatus, (*b*) it was impossible to give the water a double treatment of chemicals, the necessity for which will appear later. The last addition to the plant was made in 1918 and consisted of a new settling basin of 800,000 gallons capacity (no. 1 on figure 2) and four new filters (nos. 10, 11 and 12).

THE RAW WATER

The nature of color in water

The exact nature of color in water has never been determined. It has been the custom to state that the coloring matter was composed largely of organic substances in solution of the nature of tannic acid, humic acid, the tannates, gallates, glucosides, etc. The coloring matter is certainly of an organic nature, since it can be readily destroyed by ignition of the total solids. High color in water is generally accompanied by a high iron content. The average of a number of determinations of iron on the Cape Fear water show it to be in excess of 1 p.p.m. Some writers (9) believe that the coloring matter in water is intimately associated and possibly in combination with the alkalinity. Our views on the nature of color in water have been considerably clarified by the work of Saville (10). This investigator has shown by a very interesting series of experiments "that color in water is certainly in the colloidal state and that it exhibits definite characteristic electrical properties which substantiate this contention." Moreover, Saville states that experiments made in the Laboratory of Hygiene and Sanitation at Harvard University indicate that color in water behaves as a colloid when subjected to dialysis and to examination in the ultra microscope. To quote from Saville's conclusions,

> Color in water in large part exists in the form of colloidal suspensions of ultramicroscopic particles. Some of the color may be due to colloidal emulsoids. A small part of the color is probably due to non colloidal material, organic acids, and neutral salts in true solution. The colloidal coloring matter, whether suspensoids or emulsoids, carries an electrostatic charge. This charge may be positive or negative depending on the character and source of the water and varying in different waters. Color in water is usually due to negatively charged colloidal material. . . . . Since these particles carry an electric charge and are in colloidal suspension, they obey the laws of cataphoresis when an electric current is sent through a colored water. The particles are attracted to the electrode of opposite sign from the charge which they carry. They are discharged, flocculate, and precipitate, with consequent reduction in the color of the water.

The theory outlined above explains very satisfactorily the phenomena observed at the Wilmington plant. Experiments by G. F. Catlett and the writer tend to show that the coloring matter in the raw water is largely due to colloidal matter, which for the greater part of time at least is negatively charged.

Physical characteristics

As has been stated the raw water is always highly colored and frequently turbid. Normally the water has a perceptible vegetable odor. The following table gives an idea of the variation in color and turbidity.

YEAR	COLOR			TURBIDITY		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	133	350	20	94	650	10
1921	161	260	40	48	200	0
1922	160	300	70	33	410	0
	151	350	20	58	650	0

Chemical characteristics

As has been stated the physical quality of the water is subject to wide fluctuation but chemically there is very little variation, except in case of sea water contamination which is fortunately of rare occurrence. The following results of analysis indicate the general type of water.

Sanitary

George C. Whipple Report December 7, 1911

Sample taken November 12, 1911

	p.p.m.
Alkalinity	14.0
Chlorine	8.0
Oxygen consumed	16.9
Nitrogen as nitrate	0.070
Nitrogen as nitrite	0.000
Nitrogen as free ammonia	0.026
Nitrogen as albuminoid ammonia	0.270
Total residue	107.00
Loss on ignition	40.00
Fixed residue	67.00

Industrial

(Average of weekly determinations for one year United States Geological Survey 1906–1907).

Total iron (Fe)	1.3
Silica (SiO_2)	9.9
Calcium (Ca)	5.0
Magnesium (Mg)	1.5
Sodium and potassium (Na&K)	7.2
Carbonate radicle (CO_3)	0.0
Bicarbonate radicle (HCO_3)	25.0
Sulphate radicle (SO_4)	3.2
Nitrate radicle (NO_3)	0.2
Chlorine (Cl)	5.8
Total dissolved solids	57.0

The following is a summary of the results of daily routine tests for the past three years.

YEAR	ALKALINITY			CHLORINE		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	8	15	4	21	320	5
1921	11	21	6	155	3,265	4
1922	10	18	4	15	380	3
	10	21	4	64	3,265	3
	FREE CO_2			TOTAL HARDNESS		
1920	8	15	2	21	34	12
1921	8	15	2	37	326	10
1922	6	14	2	8	17	0
	7	15	2	22	326	0

Bacteriological characteristics

Bacteriologically the quality of the water is subject to great variation as has been explained under "Source of supply." The following summary taken from the annual reports will serve to show this.

Results of daily bacteriological tests on the raw water

YEAR	TOTAL BACTERIA PER CUBIC CENTIMETER AT 20°C.			TOTAL BACTERIA PER CUBIC CENTIMETER AT 37°C.			B. COLI PER 100 CC. AVERAGE
	Average	Maximum	Minimum	Average	Maximum	Minimum	
1920				999	6,500	50	530
1921	2,972	36,000	50	3,085	30,000	75	3255
1922	1,781	27,000	170	1,333	20,000	100	2712
	2,376	36,000	50	1,806	30,000	50	2166

The following table has been prepared to show the seasonal variations in the number of bacteria in the raw water. Monthly averages of daily counts at 20°C. and 37°C. together with B. coli tests are shown. These data indicate that the 37° bacteria and B. coli increase from a minimum in the winter months to a maximum in the summer. The 20° count is higher than the 37° count in winter and lower in summer. This tends to prove that the death rate of body temperature organisms in the Cape Fear Water is lower in summer than in winter. Doubtless the dry weather usually experienced in the fall tends to cause a maximum at that time.

Comparative bacterial counts on gelatine at 20°C. agar at 37°C and B. coli per cubic centimeter on the raw water

MONTH	BACTERIA PER CUBIC CENTIMETER		B. COLI PER CUBIC CENTIMETER
	20°C.	37°C.	
1921			
January	639	496	
February	445	332	
March	715	460	
April	4,475	1,443	
May	2,916	1,757	23.80
June	3,502	3,057	43.20
July	3,912	4,488	38.30
August	3,507	5,495	38.30
September	3,055	5,992	42.50
October	6,945	9,030	60.10
November	3,807	3,173	73.30
December	1,739	1,298	46.20
1922			
January	1,610	873	25.60
February	1,766	561	10.60
March	1,545	255	18.70
April	1,883	653	26.00
May	1,292	818	36.10
June	1,764	2,337	37.60
July	1,147	2,009	37.40
August	1,524	1,940	27.30
September	723	833	25.80
October	1,023	1,117	32.50
November	1,232	1,092	22.20
December	5,860	3,510	25.80

Coagulation and decolorization of the raw water

At Wilmington coagulation of the water is brought about by the addition of sulphate of alumina and lime. The general principle of the reaction is summarized by Saville (10) as follows:

> It may be said that, when most successfully used, the action depends upon the discharge of a negative color colloid by the positively charged ion of the coagulating agent and the positively charged hydroxide which is formed. The consequent neutralization of the charged color colloids results in flocculation, precipitation and decolorization. This process is materially aided by the mechanical removal of the color colloids by the hydroxide floc which is formed. When clarification is obtained with difficulty, the reason is frequent that the color colloids in the water bear a positive charge. Hence they are not discharged by the positive ion of the dissociating coagulant. Under such conditions the removal of color is supposed to be entirely a mechanical process resulting from enmeshment and straining out of the color colloids by the precipitated hydroxide floc.

Some observers claim that when a highly colored water and a turbid water come together mutual precipitation of the colloids take place with resulting clarification of the water. Since both color and clay turbidity normally bear a negative charge it is hard to see how such a view can be maintained. On the contrary when the colored Northeast Branch mixes with the turbid Northwest Branch of the Cape Fear the resulting mixture retains both color and turbidity and is much harder to clarify with sulphate of alumina than either water alone.

Given a well designed filter plant, success or failure in the purification of a highly colored water rests almost entirely on the basin treatment. In treating waters of this type the practice has tended toward a longer period of contact and a somewhat higher velocity than is customary in treating turbid waters. However, experience at Wilmington has taught that regardless of the retention time, velocity or mixing, it is impossible to secure decolorization unless the amounts of chemicals applied are very carefully balanced. The amount of alkalinity necessary to react with one grain per gallon filter alum is usually given as 7.7 p.p.m. ($CaCO_3$). In a recent paper Mr. R. S. Weston (11) makes the following statement:

> At present sulphate of alumina is added until coagulation takes place, and, in most cases, soda is added to maintain an alkalinity of at least 7 p.p.m. in the water delivered to the mains.

Catlett (12) has explained how the system of adding all the alum and alkali to the water before sedimentation failed at Wilmington. After many trials he adopted the practice of adding only a portion of the alkali with the alum and after coagulation and partial sedimentation had taken place, of adding a secondary dose of alkali to furnish a final alkalinity of 10 p.p.m. Greatly improved results were secured. Further study of this subject has led to the conclusion that best results are obtained in the first basin by allowing an amount of alkali equivalent to 4 p.p.m. ($CaCO_3$) for each grain per gallon of alum. The amount of alkali required in addition to the natural alkalinity is added with the alum in the pump suction in the form of calcium hydroxide. For plant control the alkalinity furnished by commercial hydrated lime, 70 to 75 per cent $Ca(OH)_2$, may be considered equivalent to $CaCO_3$ as will be seen from the following equation. Assuming 74 per cent $Ca(OH)_2$:

$$\text{p.p.m. hydrated lime} \times \frac{74}{100} \times \frac{CaCO_3}{Ca(OH)_2} = \text{p.p.m. } CaCO_3$$

The secondary dose to bring up alkalinity is usually added in the last basin but may be added to the clear well.

Let us now focus our attention on some of the results obtained by the application of hydrogen ion determinations to water purification. Work by Wolman and Hannan (14), Bayliss (15), and Hatfield (16), as well as many others have led to the conclusion that there is an optimum pH valve around which good coagulation results may be expected and that, if the pH varies much from the optimum, very little or no floc may be expected. The location of this optimum point seems to be about 7.0 on the waters reported thus far. The writer believes that this point varies with different waters and that it may be anywhere on the pH scale from 4.4 to 7.6. Theriault and Clark (13) have developed titration curves for alkali and alum and have carried out a very interesting series of experiments where pH was plotted against time required for the formation of visible floc. They have demonstrated that the optimum (iso-electric) point for the precipitation of aluminum in pure and buffered solutions is very close to pH 5.5. They conclude that, "The hydrogen ion concentration of the final mixture of water and alum is of fundamental importance in the formation of floc."

In actual practice we are not dealing with pure or carefully buffered solutions. The raw water contains small quantities of a great

number of substances in solution. In the case of a highly colored water there is a relatively large amount of colloidal coloring matter. It is possible that this coloring matter has an optimum pH at which it is precipitated, although the writer has not succeeded in discovering any evidence of this fact. It is more certain that there is a very definite optimum pH for the coagulation of alum-color mixtures in water. While the optimum point for the precipitation of $Al(OH)_3$ is doubtless 5.5, it seems probable that there is likewise a definite optimum pH for the precipitation of alum and color. The precipitate in this case is undoubtedly very complex, but we may represent it as a mixture of (Al^+ $Color^-$) and (Al^+ $(OH)_3$ $Color^-$).

It has been the custom at this plant to determine the dose of chemicals by floc tests in jars. A number of clean glass jars are filled with one liter of water each, and various amounts of alum and lime solutions are added to each. The dose in the jar showing best decolorization in the shortest time with a minimum of chemicals is selected for application to the plant. Invariably the decolorized water in this jar shows a pH very near 4.4 and the ratio parts per million alkalinity to one grain per gallon of alum will be found very close to 4:1. Similar tests on the treated water after practically all the color has been removed show an optimum pH between 5.4 and 5.6 which demonstrates that the color present was responsible for the lower optimum pH obtained on the raw water. The writer has prepared three curves to demonstrate the relations involved. It should be stated that there is always a minimum value of alum below which complete decolorization cannot be obtained. This is to be expected since there must be at least sufficient alum present to completely react with the color if complete precipitation is to be attained. For this reason no values have been plotted for experiments where the dose of alum was too low to secure complete reaction. As may be expected, some of the values do not fall on the curve and this is not surprising, since, by the method used, the observer was required to carry in mind a picture of the condition represented as "excellent," "good," etc. This is a very poor method at best, for a floc might have been classified as "excellent" on one day and a floc of exactly the same quality might have been classified as "good" on another day. It is fully realized that a comparison between pH and the amount of alum remaining in solution would have been much better, but this investigation must await the perfecting of an analytical method for the determination of small amounts of aluminum. How-

ever, the general trend of the curve is unmistakable. The variations in the experiments are shown below:

August 7, 1922. Alum constant, amount of alkalinity varied.
August 8, 1922. Alum constant, amount of alkalinity varied.
August 24, 1922. Alum constant, amount of alkalinity varied.
November 11, 1922. Alum constant, amount of alkalinity constant.
November 11, 1922. Alum constant, amount of alkalinity constant.
November 11, 1922. Alum constant, amount of alkalinity varied.
February 17, 1923. Alum varied, amount of alkalinity constant.

In figure 3 is shown the degree of clarification plotted against pH. The region for the formation of an excellent floc is very narrow, pH

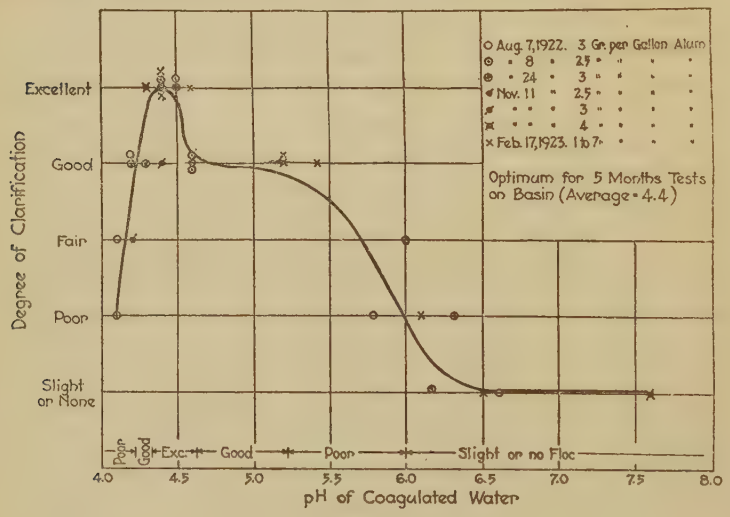


FIG. 3

4.3 to 4.6. A good floc may be expected between pH 4.2 and 5.2. Outside these limits poor results will be obtained. In this connection the following quotation from Theriault and Clark (13) is of interest, "We would expect that a water of low alkalinity or low total salt content should require a much more delicate adjustment of the dose of alum than a water of high alkalinity or high salt content."

In figure 4 degree of clarification is plotted against the ratio of parts per million alkalinity to one grain per gallon alum. In general this curve is similar to that of figure 3 but does not show quite as narrow a range for the production of an excellent floc. It indicates

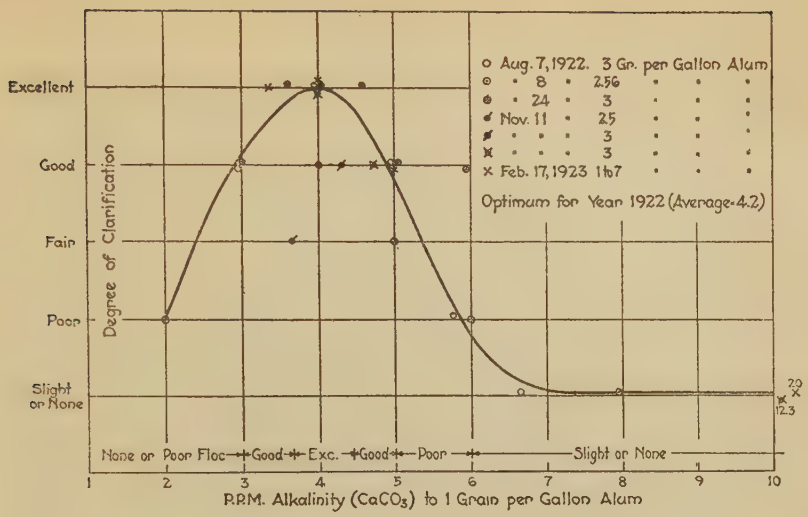

Excellent
Good
Fair
Poor
Slight or None
Degree of Clarification
○ Aug. 7, 1922. 3 Gr. per Gallon Alum
⊙ " 8 " 2.56 " " "
◐ " 24 " 3 " " "
◪ Nov. 11 " 2.5 " " "
⊠ " " " 3 " " "
× Feb. 17, 1923 1 to 7 " " "
Optimum for Year 1922 (Average-4.2)
None or Poor Floc
Good
Exc.
Good
Poor
Slight or None
1 2 3 4 5 6 7 8 9 10
P.P.M. Alkalinity ($CaCO_3$) to 1 Grain per Gallon Alum

FIG. 4

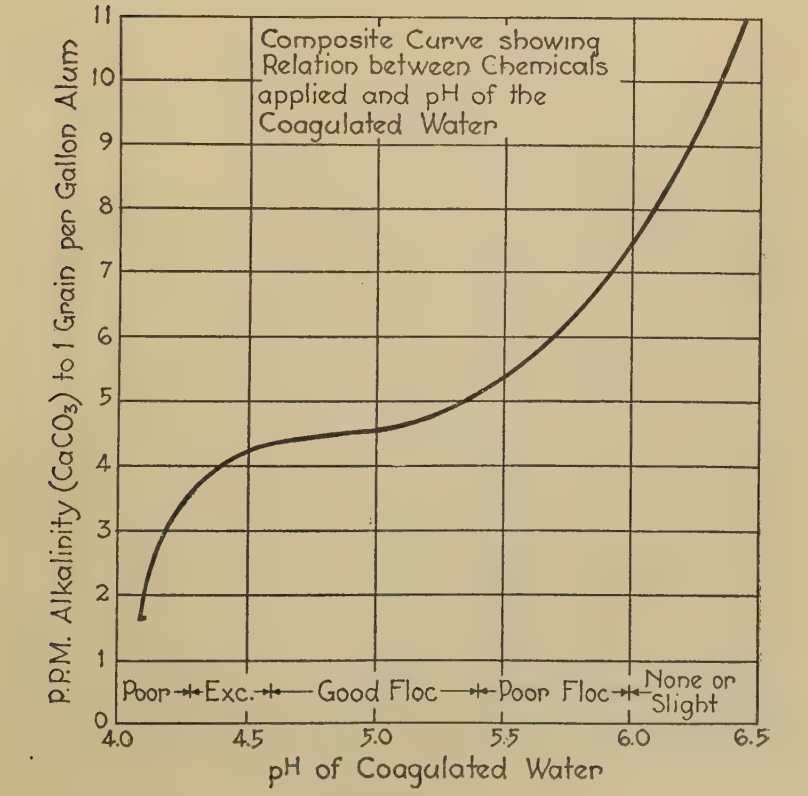

Composite Curve showing Relation between Chemicals applied and pH of the Coagulated Water
P.P.M. Alkalinity ($CaCO_3$) to 1 Grain per Gallon Alum
0 1 2 3 4 5 6 7 8 9 10 11
Poor
Exc.
Good Floc
Poor Floc
None or Slight
4.0 4.5 5.0 5.5 6.0 6.5
pH of Coagulated Water

FIG. 5

that good results will be obtained between 3.0 and 5.0 with an optimum of 4.0. This curve represented our information on the subject up to 1922.

Figure 5 is a composite curve which shows the relation of the pH of coagulated water to the alkali-alum ratio. In a way it correlates our knowledge on the subject, past and present. It shows that best results will be obtained when the pH of the coagulated water is 4.4 and the alkali-alum ratio is 4.

With this information we have something definite with which to work. Assume that we have a raw water of known alkalinity, but that the amount of chemicals required is unknown. A series of jar tests will indicate the minimum dose of alum to be used. The ratio of alum to alkali can be adjusted by addition of lime hydrate. It is then only necessary to maintain the basin effluent at pH 4.4. While this looks easy it will be found sufficiently difficult in practice.

ALUM IN THE EFFLUENT

The above procedure works well at Wilmington for about nine months out of the year. The reaction appears to be instantaneous. When the temperature of the filtered water falls to 10°C. or less, trouble is experienced from alum in the effluent. The water in the basin is coagulated and decolorized, but the fresh filter effluent has a slight opalescence. On standing twelve to twenty-four hours the familiar precipitate of $Al(OH)_3$ forms. The only explanation appears to be that at low temperatures the reaction to form $Al(OH)_3$ is retarded; the greater part of the aluminum is precipitated and the decolorization proceeds as usual, but a small amount of unprecipitated alum (probably as colloidal hydroxide) passes the filters to appear finally in the filter effluent. It has been noticeable during the winter that the optimum pH 4.4 is attained only occasionally and that the pH ends toward a higher value in spite of every effort to reduce it. It is believed that this condition is intimately connected with the presence of alum in the effluent. Increasing the period of retention in the basins (twenty-four or more hours) or heating the influent suggest themselves as possible remedies. Both would be expensive. The large basin would not be necessary and might prove unsatisfactory in warm weather due to rapid settling of the floc. A study of the effect of temperature on the precipitation of aluminum would be of great assistance. Observations of the

filters indicate that there is less likelihood of alum passing a newly washed filter than one with considerable loss of head. This indicates that the problem is partly mechanical at least.

CHARACTER OF THE TREATED WATER

Chemical characteristics

Chemically the quality of the city water leaves little to be desired except when it is contaminated with sea water, which condition is fortunately of rare occurrence. The year 1921 was exceptional for the amount and long duration of the salt contamination. During 1920 and 1922 no complaints were received on account of salt in the water. In general it may be said that an amount of salt in water equivalent to 200 p.p.m. chlorine may be detected by persons with a delicate sense of taste; 300 p.p.m. chlorine is noticeable to almost anyone; while an amount in excess of 500 p.p.m. is distinctly unpleasant. The following is a summary of daily routine tests over a period of three years.

Results of chemical tests on treated water

YEAR	ALKALINITY			CHLORINE		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	6	14	2	16	300	4
1921	7	17	3	164	3,010	6
1922	6	20	2	17	545	5
	6	20	3	66	3,010	4
	FREE CO_2			TOTAL HARDNESS		
1920	4	14	1	33	59	13
1921	4	10	1	57	322	25
1922	4	10	2	28	45	16
	4	14	1	39	322	13

The following are the averages of monthly nitrogen determinations over a three year period.

Free ammonia	0.022
Alluminoid ammonia	0.088
Nitrogen as nitrite	0.0
Nitrogen nitrate	0.04

Physical characteristics

With the plant operating perfectly the city water is normally soft, with little odor or taste and of pleasing appearance. Owing to the nature of the raw water it is impossible to produce an effluent which is physically perfect at all times. In fact it frequently happens that the tap water in the city is colored or turbid or both. This state of affairs is due primarily to the continual variations in the quality of the raw water. It is partly due to the effect of cold weather on the purification processes which results in the deposition of aluminum hydrate in the treated water as has been explained. It is partly due to the avidity with which soft waters of this type attack iron, the dissolved iron reappearing as a rusty discoloration or precipitate in hot water piping. Finally, it is due to some extent to defects in plant construction and unavoidable errors in operation.

Summary of daily tests for color and turbidity on the treated water

YEAR	COLOR			TURBIDITY		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	9	50	0	8	60	0
1921	14	45	0	1	25	0
1922	15	60	0	2	20	0
	13	60	0	4	60	0

Bacteriological characteristics

The filtered water before chlorination would not be considered safe for drinking without further treatment, as will be seen from the following summary.

Summary of the daily bacteriological tests on the filter water (not chlorinated)

YEAR	AVERAGE BACTERIA PER CUBIC CENTIMETER ON AGAR AT 37°C.	AVERAGE B. COLI INDEX; PER 100 CC.
1920	35	73.00
1921	52	16.10
1922	43	21.97
Average.....	43	37.02

The filtered water can be sterilized readily by means of liquid chlorine and the resulting effluent meets the Treasury Department

Standard for drinking water on common carriers. However, in accomplishing this the chlorine treatment loses its identity as a factor of safety and becomes a necessary part of the purification process. The following is a summary of bacteriological results on the filtered and chlorinated water over a three year period.

YEAR	TOTAL BACTERIA PER CUBIC CENTIMETER ON GELATINE AT 20°C.			TOTAL BACTERIA PER CUBIC CENTIMETER ON AGAR AT 37°C.			AVERAGE B. COLI INDEX PER 100 cc.
	Average	Maximum	Minimum	Average	Maximum	Minimum	
1920				11	99	0	0.32
1921	15	900	0	24	620	0	0.53
1922	20	600	0	34	1400	0	0.32
	18	900	0	23	1400	0	0.39

Hydrogen ion tests

During the past year a large number of hydrogen ion tests have been made. The colorimetric method without buffers was used (17). The standards and indicators were prepared from materials procured from the LaMotte Chemical Company. The pH values given in this article are not offered as being strictly exact, but simply as determined in the course of routine work. The following table shows the results obtained on the Wilmington water over a period of five months. It will be observed that the average pH value on the basin effluent coincides with the experimental optimum shown in figure 3. That this constitutes a valuable confirmation of the laboratory data is apparent in view of the fact that the basin has been operated primarily to produce the best appearing floc and that the resulting pH has been taken only for confirmation and record.

Results of pH determinations on Wilmington water, 1922

MONTH	NUMBER TESTS	AVERAGE	MAXIMUM	MINIMUM
Raw water				
August	48	6.0	6.4	5.6
September	58	6.3	7.6	5.8
October	60	6.3	6.8	6.0
November	16	6.4	7.0	6.2
December	7	6.5	6.8	6.2
	189	6.3	7.6	5.6

Results of pH determinations on Wilmington water, 1922

MONTH	NUMBER TESTS	AVERAGE	MAXIMUM	MINIMUM
Treated water				
August	45	6.1	6.6	5.8
September	58	6.2	7.8	5.8
October	58	6.3	7.0	5.4
November	13	6.1	6.4	5.8
December	6	6.1	6.3	5.8
	180	6.2	7.8	5.4
First basin effluent				
August	21	4.2	4.4	4.0
September	20	4.3	4.6	4.2
October	25	4.3	4.8	4.1
November	18	4.5	5.2	4.2
December	24	4.9	5.6	4.2
	108	4.4	5.6	4.0

General operating statistics

Table 1 has been prepared to show the operating results on the plant and it includes the most interesting data from the annual report, for three years. The figures for amounts of water treated have been computed from the displacement of the pressure pumps and are not strictly accurate. All other figures except total cost are based on the pumpage and are relatively accurate. The total cost of purifying the water includes low lift pumping, chemicals, labor for pumping and filter operation, repairs and labor on repairs, wash water, supervision and laboratory. It does not include depreciation or cost of pressure pumping.

The average amount of water treated daily is slightly in excess of 3 m.g.d. which is only about one-half the rated capacity of the plant. This explains why the rate of filtration is only 88 instead of 125 m.g.d. It has been found that somewhat more uniform results are obtained at the lower rate. There is very little variation from year to year in the average amounts of chemicals required to treat the water. The decrease in the amount of coal required is due to improvements to the power plant.

TABLE 1

Summary of operating data for three years

YEAR	GENERAL STATISTICS										
	Water filtered (million gallons)		Wash water per cent (average)	Hours in operation per day (average)	Yield million gallon per acre daily (average)	Rate million gallons per acre daily (average)	Length of filtered runs (average hours)	Basin time (average hours)	Average parts per million alkalinity to 1 gr./gal. alum (Basin No. 1)	Average parts per million alkalinity to 1 gr./gal. alum (total)	Pump duty million foot pounds per 100 lb. coal (average)
	Total	Average									
1920	1,158	3.165	2.36	23.6	64	79	56	11.7	5.2	5.5	14.90
1921	1,146	3.140	2.81	21.3	64	83	42	10.4	5.0	6.4	16.00
1922	1,235	3.384	2.93	23.1	69	101	31	9.5	4.2	5.8	17.45
Average...	1,180	3.230	2.70	22.7	66	88	43	10.5	4.8	5.9	16.12

YEAR	COAL AND CHEMICALS (AVERAGES)							ANNUAL COST OF PURIFICATION	
	Alum		Lime		Chlorine		Coal		
	Pounds per million gallons	Grains per gallon	Pounds per million gallons	Grains per gallon	Pounds per million gallons	Grains per gallon	Pounds per million gallons treated	Total cost	Cost per million gallons treated
1920	429	3.00	121	0.85	5.95	0.041	2,497	$36,458.72	$31.48
1921	390	2.73	114	0.80	5.53	0.039	2,367	33,822.20	29.51
1922	403	2.82	104	0.73	5.17	0.036	2,155	35,248.38	28.54
Average...	407	2.85	113	0.79	5.55	0.039	2,340	$35,176.43	$29.84

CONCLUSIONS

The purification of the present raw water requires careful technical supervision both night and day. The dosage of chemicals must be very carefully controlled and at times it must be varied almost continually to meet the changes in the character of the raw water. The process is an expensive one, the average cost per million gallons treated for the three year period being $29.84. Chlorination is necessary to produce an effluent of satisfactory bacteriological quality. In cold weather trouble may be anticipated from the presence of aluminum hydroxide in the filtered water. Laboratory tests and actual experience with the plant indicate that there is an optimum hydrogen ion concentration at which flocculation and decolorization occur and that this point is close to pH 4.4. This

optimum can be secured when the amount of alkali (p.p.m. $CaCO_3$) allowed per one grain per gallon filter alum (17 per cent Al_2O_3) is about 4 to 1. The pH zone for optimum conditions is narrow and outside this zone poor results may be expected. For the purification of this water in cold weather it appears that a long retention period (at least twenty-four hours) or a system for heating the raw water would be advantageous.

After sixteen years experience with this water Wilmington is now in the process of making extensive changes in the water supply system. The changes affecting the filtration plant are:

A new raw water intake on the turbid Northwest (branch) Cape Fear, five miles above the city; installation of electrically driven pumping machinery; the construction of a mixing chamber; installation of dry feed machines for chemicals; modification of the sedimentation basins to reduce velocity; substitution of high velocity for air and water wash; resanding of filters; installation of a Venturi meter.

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THE DEGASIFICATION OF WATER[1]

By J. R. McDermet[2]

The material for this paper is based upon the experiences obtained in the development of a successful apparatus for the degasification of water. Part of it is based upon work in the research laboratory, and part upon results gained in the application of these degasification units located variously over the entire United States, and ranging in capacity from an hourly water-handling rate of 4000 to 1,100,000 pounds. The success of this apparatus is based as much upon the observance of good rules of engineering as upon the proper regard for chemistry, but, because the interest of this audience is primarily directed toward the industrial and potable uses of water, the scope of this paper will be limited to the characteristics of various commercial apparatuses, as they concern water.

Primarily, the apparatus derives its commercial merits from the fact that it is able to prevent corrosion in piping. Several methods are available to secure the same results other than degasification. For instance, certain materials have immunity from specialized corrosion attacks, but none of them is ordinarily able to meet satisfactorily all the conditions which natural waters impose from time to time, and, simultaneously, be within permissible cost. It is also possible, in many cases, to control properly the hydrogen ion concentration of the water so that the pipe lines will be either immune from corrosion or covered with insoluble coatings precipitated from the dissolved solids in the water. These also are objectionable in that it is not alway possible to control the hydrogen ion concentration without interfering with the usefulness of the water, or to precipitate a protective coating which will be permanent. Degasification apparatus, however, has not had an economic field other than the removal of dissolved gases from hot water, the primary reason being that investment costs for large water handling capacities have been greater

[1] Presented before the Chemical and Bacteriological Section meeting, Detroit Convention, May 24, 1923.

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than the damage which cold water corrosion has caused. Water has its maximum corrosive virulence at approximately 180°F., and most waters are relatively harmless at normal atmospheric temperature. Pipe lines of great length or pipe lines carrying salt water may, however, profitably be protected. Degasification of water from a commercial standpoint is an insurance feature for protecting pipe lines.

The degasification of water may be obtained by one of two methods which broadly may be designated as chemical or mechanical. The chemical method is, however, more particularly a de-oxygenation rather than a degasification, in that ordinarily only oxygen is removed in the process and carbon dioxide and hydrogen may actually be increased. The gases which it is generally desired to remove in water degasification processes are the gases dissolved from the air, and consist of oxygen, nitrogen, hydrogen, and carbon dioxide, in proportions regulated by their partial pressure in the atmosphere and their solubility factor in solution.

The chemical method consists in bringing the water to be de-oxygenated, after first heating it, into a tank filled with a collection of high manganese steel scrap; the intention being that the oxygen in the water shall attack the steel scrap and corrode it, this being a cheap and readily replaceable material. The method, therefore, has an immediate attractiveness in that it deals with corrosion in its own terms, and protects pipe lines by destroying the corrosive effect of the water. The oxygen in the water is consumed in producing some form of iron oxide from the scrap iron. Just which oxide will be formed depends upon the temperature, the oxygen concentration in the water entering, and the rate at which the apparatus is operated. Some waters, particularly those high in carbonate and dissolved carbon dioxide, may produce a conglomerate within the iron reaction chamber, which may speedily clog up the apparatus and render it inoperative. In addition, the products of normal reaction in these scrap iron chambers, are colloidal or gelatinous, and are extremely difficult to filter unless the hydrogen ion concentration is controlled by a coagulant within a zone to precipitate the iron oxide in a filterable form. The rust products are of course not dangerous from the standpoint of producing further corrosion, but are extremely distasteful.

There is also an unfortunate tendency for these chemical degasifiers to become inoperative due to polarization, the successive layers of

oxide forming upon the active material and eventually rendering it immune. This disadvantage, however, has been overcome in a foreign type of the apparatus, in which the water is passed through a series of these de-oxygenating chambers, and in which the degasification is through the serial action. The direction of flow through the chambers is periodically reversed, and as a result the ferrous oxide, for instance, which formed at one stage in the previous cycle, itself acts as a vigorous de-oxygenator at a different stage in the following cycle when the flow direction is reversed. This principle of reversibility seems to be a distinct improvement in the art of using this type of degasifier.

The other method of degasification may be designated as that of partial pressure control, and in its various commercial forms is a more or less exact application of Henry's law. Henry's law, stated in its simplest form, is to the effect that permanent gases which do not unite chemically with the liquid, dissolve in the liquid in proportion to their partial pressure on its free surface at any arbitrary temperature. Reduced to a more mathematical form, the solubility is equal to a proportionality constant, dependent upon temperature, nature of gas, chemical character of liquid, etc., times the partial pressure. The partial pressure is that of the particular gas, and the solubility is of course independent of the partial pressure of any other gases which may be present, or the total pressure on the surface of the liquid.

Henry's law immediately suggests a means of degasification, viz., that of bringing the liquid into equilibrium with a gaseous atmosphere in which the partial pressure of the gases, which it is the desire to eliminate, will be reduced substantially to zero. Any method of hastening equilibrium, such as agitation and exposing a large surface, contributes to the operating efficiency of the apparatus.

Several different types of apparatus are available in America for accomplishing this purpose. One of them at least has met with a large measure of commercial success, and is the apparatus with whose development the writer has been directly concerned.

One type of apparatus which has had limited use in connection with small capacities for deaeration of hot water in building service depends upon the fact that at atmospheric boiling point the vapor pressure of the water is equal to the pressure of the atmosphere. In theory, therefore, according to Henry's law, if this water was agitated in a contained space, the pressure of the vapors would be the pres-

sure of the atmosphere, and the enclosed space would be entirely filled with water vapor, together with the small admixture of air with this water vapor as the air was driven off from the liquid. The partial pressure of the air would be substantially zero for the simple reason that the partial pressure of the steam would be substantially atmospheric, and the sum of the two would be equal to the atmospheric value also, the difference amounting to the partial pressure of the air being, therefore, very small. These apparatuses have been fairly successful, and have given values of oxygen as low as 0.4 cc. per liter and corresponding to parts per thousand by volume under standard gas conditions, the usual way of expressing dissolved gases in water. These particular types of degasifiers have suffered the limitation, however, that they are not efficient, for, in the contained atmosphere, which is supposedly of zero partial air tension, diffusion currents have appeared, and it has been impossible to displace the air without considerable heat evolution and a positive convection with steam. When heat energy is liberated in any appreciable quantity, the process invades the realm of another type of degasifier, and any further discussion necessarily must be devoted to this other type.

A second type of degasifier has appeared on the market, in which steam is bubbled upward through nozzles, and in its passage frees the water of air. It is an awkward means of applying the previous description in that the atmosphere is virtually forced upward through the liquid instead of by the more sensible way of raining the liquid down through the atmosphere. The results, however, in the second apparatus are slightly more thorough than in the first, and the difficulties of the apparatus are more mechanical than those of proper degasification.

The Elliott process, with which the writer has been engaged, is named after its inventor, and is called a deaerator instead of a degasifier, primarily from recognition of the fact that the gases which are to be removed are normally the gases of the air. This apparatus operates through heat interchange, and at the same time is 100 per cent thermally efficient. In its operation the water is first heated to some 25 degrees above the temperature at which it is desired to use it, and then injected suddenly into a region of vacuum, in which the pressure is maintained at a value corresponding to the vapor pressure of the water at the temperature of use. These previously mentioned 25 degrees excess temperature are, therefore, available as superheat in the liquid relative to the temperature of the vacuum,

and when the water is injected, the heat immediately flashes some portion of the water into steam, evaporating it and disintegrating the rest completely. After disintegration, the water is collected and further passed back and forth over agitation spray pans to bring it into more complete contact with the atmosphere in the interior of the separating chamber. The vacuum in the separator chamber is maintained by some form of air exhausting equipment in series with a condenser, the function of which is to condense and return to the system the vapors and the heat evolved in the boiling process. The cooling water for this condenser is supplied by the water on its way to the heater, and the heat, therefore, interchanged by the condenser is returned to the heater.

This apparatus obeys Henry's law in these particulars. The water is first disintegrated by the flashing process on entrance into the region of vacuum and equilibrium is hastened by agitation. The water is further agitated over cascade pans. The net result of atomization and agitation is to increase vastly the amount of virtual free surface where the liquid is intimately exposed to the atmosphere on the interior of the separating chamber. This, therefore, is the first qualification under Henry's law. The usual temperatures at which water is used are in vapor pressure regions, in which the pressure is less than atmospheric. The employment of a vacuum, therefore, immediately reduces the total pressure in the region, and, by reducing the total, simultaneously reduces the various constituent partial pressures which comprise the sum. A controlled amount of vapor is evolved in the flashing process, which provides a regulated component of vapor pressure in the separating chamber, and this is regulated on the basis of being substantially equal to the total pressure existing in the region of separation. By the process of substitution, the partial pressure component due to air gases, is reduced substantially to zero, its value in operating apparatus lying invariably below 0.001 inch of mercury pressure, and the solubility of the gases in the water, therefore, corresponds very closely to the theoretical value indicated by this partial air tension. If the water is abstracted, therefore, from this separating chamber and its region of vacuum and put under a positive pressure without further contamination, it will remain substantially gas free.

It has been customary to employ for water free from nitrates and nitrites the Winkler Test for dissolved oxygen, with proper pre-cooling of the liquid to temperature conditions at which the Winkler

Test may be operated. It is ordinarily customary in connection with the Elliott process to speak of the liquid delivered as of zero oxygen content when it does not respond to the starch indicator test in the Winkler titration. Such a condition of oxygen solubility is, however, manifestly untrue, but the zero oxygen of commerce is so defined, and apparatus employing the Elliott process uniformly delivers water having this so-called zero standard.

For waters containing nitrates or nitrites, it is customary to employ the Lenoissier test for dissolved oxygen, which consists of determining the reduction of a calibrated ferrous sulphate solution, using phenol-safranine as an indicator. This method is preferably first calibrated upon a nitrate free water in terms of the Winkler method and then used upon waters for which the Winkler method is inapplicable. It can, however, readily be standardized directly.

The research laboratory has just completed an investigation on the behavior of the Elliott process upon dissolved carbon dioxide. The results will be forthcoming in a paper before the American Chemical Society, by Mr. D. H. Jackson, in collaboration with the present writer. It is possible, however, to summarize the results of this paper in advance by saying that the Deaerator, so-called, and as previously described, removes all free carbon dioxide and decomposes approximately 35 per cent of the bicarbonate present, most of which is precipitated, and a small part, approximately sixteen parts per million, remains in solution as calcium carbonate. This percentage value increases slightly with concentration of bi-carbonate. The pH values are changed by deaeration from slightly acid to decidedly alkaline, the change averaging 2.5 pH. The results were obtained upon water from two surface streams, one in the vicinity of Jeannette, Pa., and the other from Pickering Creek, which supplies a suburb of the City of Philadelphia. The pH values on the raw water for the series of determinations average around 6.7 and the pH on the deaerated samples 9.25. The results were obtained both from gravimetric weighing, volumetric titrations, and from gas evolution and measurement, and afford a fairly accurate check upon each other. The laboratory results have been rather curiously verified by one user of a deaerator who operates a large power laundry in Brooklyn. He has encountered a saving of approximately 35 per cent in the soap employed in the laundry process, and has been much gratified over this particular feature. It appears also that the calcium carbonate precipitated above its intrinsic solubility value comes down first as a

colloidal precipitate, which rapidly granulates and deposits as a sludge. In the large power plant units it does not appear to form the usual boiler scale which is associated with calcium carbonate, and the laboratory is at present investigating the cause. As a matter of conjecture, it may conceivably be a change from the calcite to the aragonite form of crystal. At least this is one of the present theories which the laboratory is attempting to verify.

It is difficult to say, however, whether the removal of dissolved carbon dioxide has primary significance in the prevention of corrosion It has never been the writer's good fortune to have had direct experience with an apparatus which removes only the dissolved oxygen, but it seems reasonably substantiated, from the results of others, that the removal of dissolved oxygen completely rectifies corrosion troubles. The chemical process, as outlined previously in this process for deoxygenating water, does not remove carbon dioxide, and yet it functions very well in preventing corrosion. The Elliott Deaerators remove both air and carbon dioxide, and go even a little further than Henry's law would indicate in removal of carbon dioxide. The carbon dioxide-carbonate equilibrium is of course a reversible one, which is displaced with considerable rapidity under the proper conditions.

Not all water supplies produce corrosion of the same virulence, and it is desirable, therefore, to direct attention to the term aggressive CO_2 as originated by Massink and Heyman on the Water Supplies of Holland, and which has previously been discussed in the proceedings of this Association. Such waters as exhibit CO_2 have pH values almost invariably on the side of acidity. Whether the significance of CO_2 from the corrosion standpoint lies in this pH value is open to question, but it is a matter of experience with the performance of Elliott Deaerators that the regions which exhibit the most severe pipe corrosion are also the regions in which the water either is aggressive, or tends to be aggressive, and in which the pH values are invariably slightly in the acid zone. If water supplies are ever surveyed from a standpoint of potentiality to produce corrosion, this pH value in connection with the CO_2 content is the most significant factor concerning them, provided they are free from contamination due to either sea water or sewerage, neither of which of course would be contained in an industrial and sanitary supply.

It is not reasonable to expect, nor is it found in practice, that any pipe material will be immune from corrosion in the presence of dis-

solved oxygen. It is, however, readily observable in the record of Deaerator sales, that certain localities are very much better customers than others. For instance, the territory bordering both the Atlantic and the Pacific Oceans, with few exceptions, furnishes the best market. The Great Lakes territory furnishes the least. Pipes of average commercial purity have a life along the Atlantic seaboard which varies from six to eight years on the average. In the Great Lakes region, such as Detroit, the usual life varies from fourteen to sixteen years.

In the protection of hot water service pipe lines another advantage for degasification is to be observed, viz.—that stoppage of pipes due to corrosion products is removed. Frequently on aggressive waters the corrosion products so impede the flow as to limit the usefulness of the pipe before it is actually perforated. These corrosion products usually consist of an iron oxide calcium conglomerate of which 70 per cent is iron oxide, usually in the ferric form.

The removal of corrosion products from pipe lines is apparently based upon the reversible reaction of the ferrous-ferric hydroxide equilibrium. The ferrous hydroxide is soluble and does not collect in the pipe, while the ferric hydroxide is decidedly insoluble and in addition acts as a very effective binder for other scale forming material. When deaerated water is fed through a pipe network partly filled with these stoppage products, the ferric hydroxide is slowly reduced to ferrous, and the scale product is to some extent dissolved, but primarily detached and removed as a sludge from some low point in the system. The reversibility of the reaction is very slow, however, and it ordinarily takes in practice from four weeks to three months to clear pipe lines completely. The fact that they can be cleared by this simple process of feeding deaerated water is a big commercial advantage, although not strictly a conservation measure. It does not seem, however, that either the conglomerate, which may be at present mixed with the iron hydroxide, or the removal of CO_2 along with the deaeration process is involved in the removal of corrosion products from pipes, for all types of degasifying apparatus yield virtually the same advantage, the only difference being a question of time, depending slightly upon the degree of oxygen removal which the degasifier secures. It is undoubtedly, however, purely a phenomenon involving oxygen, in which the equilibrium of the ferrous-ferric hydroxide relationship is controlled by the oxygen content of the solution.

It is fairly definitely established that partial deaeration in itself will completely remove corrosion products, and that the minimum value necessary to secure good service in this particular is 0.6 cc. per liter of oxygen. It seems also that the effective removal of corrosion products and the reversing of this previously mentioned equilibrium is also a most excellent gauge of the amount of oxygen which will produce pipe pitting. Corrosion, even when the oxygen content of water is sufficient to remove corrosion products, goes forward actively, but in the ferrous rather than the ferric form, in which the attack is more widely distributed and not localized so rigidly as to form pitting. It has been definitely established in our experience, however, that a minimum value of 0.15 cc. per liter of dissolved oxygen is still sufficient to produce corrosion, and, under the proper temperature conditions encountered in boilers, also to produce pitting. It is also established in the case of boilers and economizers fed with distilled water that corrosion is absolutely prevented if the oxygen content is kept below the zero value as previously defined. The zone lying below 0.15 cc. is, however, not definitely explored in a commercial sense. By this we mean that the results have not been based upon large scale experiments.

Chlorination of water supply does not seem to have any connection with corrosion, except in some few cases of abuse by over-chlorination. The water becomes unpalatable long before it becomes aggressively corrosive. The chemist's procedure in analysis, however, using phenol-phthalein and methyl-orange as indicators for acidity, is open to considerable criticism. It is very desirable to emphasize, as coming from an outside and a commercial point of view, the necessity and the desirability of keeping accurate records upon hydrogen-ion concentration of the water supply. Aside from the purity of the water for potable uses, this factor of hydrogen ion concentration is one of the most significant things about it. The auto-colloidal hypothesis of Friend, in which corrosion is regarded as accelerated by ferric hydroxide colloid is becoming increasingly useful in corrosion engineering work, as opposed to the earlier electrolytic hypothesis of Whitney. This auto-colloidal hypothesis is along with other variables intimately involved with the hydrogen ion concentration, primarily in regard to the stability of the colloid, which is regarded as a catalyte. It is gratifying, therefore, from a commercial and economic point of view, to notice the interest which is being increasingly

displayed in your Association activities toward the proper interpretation of hydrogen-ion concentration in water supply.

Deaeration of water has recently opened up another field of interest to the water works chemist, viz., the possibility of manufacturing clear water ice on water supplies of nominal hardness by the process of deaeration, rather than distillation. The deaeration process on what might arbitrarily be called soft water is equally effective and vastly cheaper, and will probably encourage the extensive use of raw water ice.

It has been extensively demonstrated on a big scale and in a variety of places that deaeration on the normal water supplies, which municipalities furnish may extend the life of pipe lines indefinitely. It is altogether possible, with such improvements in water supply as your Association will make in the future, that deaeration, together with the improved water supplies, will entirely prevent corrosion in a commercial sense.

WATER SOFTENING BY BASE EXCHANGE[1]

By Gerald C. Baker[2]

INTRODUCTION

Certain complex silicates classed as zeolites are used for the softening of water. These compounds are all hydrous complex silicates ordinarily containing varying percentages of iron, aluminium, alkali earth and alkali metals. The zeolites have the property of exchanging their associated bases, sodium and potassium, for others such as calcium, magnesium, manganese, etc., which represent the hardness of water. Upon filtering water through the zeolites this exchange takes place when the hardening salts are in greater molecular proportions than similar combinations of the alkali metals. When exchange has been carried to a certain point the base exchanging power is exhausted, but the minerals may be returned to their original condition by treating with common salt solution. This produces a base-exchange directly opposite to that during the softening period, i.e., the adsorbed hardening salts are replaced by sodium and when the brine is washed out the softener is again in condition to soften water.

NATURE OF THE REACTION OF BASE EXCHANGE

Of the artificial zeolites originally prepared by Dr. Gans (1) the aluminate silicates, i.e., the alkaline earths and the alkali metals combined directly with the aluminate radical through a union of the silica and the alumina, possessed easily exchangeable bases while the aluminium double silicates, i.e., the alkaline earths and the alkalies combined directly with silica, exhibited no exchange properties. The aluminate silicates were prepared by dissolving hydrated alumina in sodium hydroxide and adding hydrated silicic

[1] Abstract of thesis prepared under the direction of Prof. Edward Bartow and submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at the University of Iowa, February, 1922. Presented in abstract at the Philadelphia Convention, May 18, 1922.

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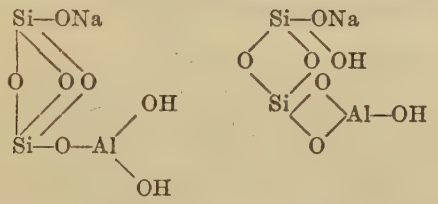
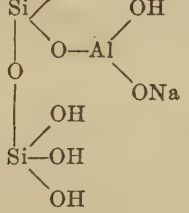
acid while evaporating to dryness on a water bath. The aluminium double silicates were prepared by dissolving hydrated silicic acid in sodium hydroxide and adding hydrated alumina under the same conditions as above. Some of the aluminium double silicates exchanged their bases when warming with sodium hydroxide. An explanation of the non-exchange of bases of some zeolites would be that the bases have replaced the hydroxyl (OH) groups of silicic acid and not that of the alumina. An example of double aluminium silicates would be analcine (2) with the empirical formula $Na_2Al_2Si_4O_{12}\cdot 2H_2O$, which could be represented graphically, as follows:



Chabasite, an example of the aluminate silicates with the empirical formula $Na_2Al_2Si_4O_{12}\cdot 6H_2O$ might be represented as follows:



According to this theory the sodium combined with the aluminate radical is the replaceable base, while an alkali metal combined with the silicate radical is not replaceable.

G. Weigner (3) attributed the base exchanging properties of the zeolites to colloidal adsorption, basing his conclusions on the fact that the colloidal aluminium hydroxide ($Al(OH)_3$) is positively charged and has a strong adsorptive power for the hydroxyl (OH) ion. The cations in equivalent quantities should be held electrostatically in the gel water.

J. Don (4) and others noted that when hard waters are filtered through permutite, practically all the softening effect takes place very rapidly, showing surface action, and after the sodium on the

surface has been replaced by calcium the reaction depends upon the speed of diffusion of the sodium from the inner portion of the mineral.

Most investigators (5) have generally agreed that the exchange depends on the ion concentration and not on the total concentration, but there are some (6), (7), who believe the change is chemical and not merely adsorption phenomena. If considered chemically the reaction may be represented as taking place ionically. If the zeolite be represented by Z and the reconditioned sodium zeolite by Na_2Z and the hardening salt by CaX we may derive the following equation as taking place in solution:

$$Na_2Z \text{ Soln.} + CaX \text{ Soln.} \rightleftharpoons CaZ + Na_2X \text{ Soln.}$$

This equation may represent the base exchange, the hardening salts precipitating the slightly soluble sodium zeolite as the insoluble calcium or magnesium zeolite and the sodium salts going into solution. The reaction is reversible and will actually take place in either direction depending upon the concentration of the reacting salts. Regeneration is accomplished by having an excess of sodium salts. During softening the removal of one of the reacting products, the sodium salts, is continuous and the reaction proceeds to the right to completion until the replaceable sodium is exhausted. All indications point to the fact that the reactions conform to the law of mass action.

HISTORY OF THE DEVELOPMENT OF THE PROCESS

In January, 1906, a patent (8) was issued to Robert Gans, Germany, for the manufacture of an artificial zeolite (permutite) for use in softening water. Soon after similar patents were taken out in various countries all embodying the preparation of artificial aluminate silicates or similar products, substitutions of boric acid being made for silica, and tin, zinc, lead, zirconium, titanium, iron and chromium oxides, etc., for alumina.

The patents for the preparation of base exchanging zeolites provide for two general methods of manufacture, (*a*) fusion of aluminous or ferrous, etc., material or silicates with alkali silicates or alkali hydroxide or carbonate; and, (*b*) precipitation by treating an alkali aluminate solution with hydrated silicic acid and drying and washing the mass.

Certain natural zeolites have been discovered which possess very readily exchangeable bases, and patents (9), (10) have been issued

providing for the treatment of a clay with sodium salts before and after heating the resulting mass to 600° to 700°C.

Another patent (11) provides for the stabilizing of green sand (glauconite) by heating to 400°C. and its subsequent use as a water softening material.

OPERATION OF ZEOLITIC SOFTENERS

The ordinary zeolitic filter consists of a water tight hollow cylindrical shell for containing the water softening material. The bottom is fitted with some type of strainer system upon which rests a bed of gravel which supports the softening material.

During the softening period the hard water passes into the top of the softener and filters through the zeolitic bed at a rate dependent upon the size of the installation and the hardness of the water. The soft water flows out at the bottom of the tank. The flow is allowed to continue until the capacity of the system is realized, i.e., as long as water of zero hardness is delivered. When the capacity has been exhausted the filter is back-washed by reversing the flow of the water through the filter.

Regeneration is then accomplished by passing a brine solution into the filter and, after standing in contact with the mineral a sufficient length of time, is flushed out, and the filter is again in condition to soften water.

ADVANTAGES AND DISADVANTAGES OF THE ZEOLITIC TREATMENT OVER OTHER METHODS OF WATER SOFTENING

The main *advantages* of the zeolite process are (*a*) a water of zero hardness (*b*) extremely simple operation (*c*) economical operation and (*d*) certainty. The *disadvantages* claimed are (*a*) it gives an increased amount of alkali bicarbonates which may break down and cause corrosion in boilers (*b*) if used for steam raising purposes the boilers must be "blown down" more often (*c*) the water must be free from sediment and (*d*) it is not as economical for extremely hard waters as the lime-soda method.

Balancing the advantages against the disadvantages conditions greatly favor the zeolitic softeners and consequently they are rapidly gaining in public favor for domestic uses, laundries, club houses, textile mills, dyeing plants, bottling works, etc., and steam raising purposes where the raw water is amenable to the zeolitic treatment.

EXPERIMENTAL

The present investigations were undertaken to study some of the more important problems dealing with zeolitic water softeners. The different points investigated are reported under separate headings.

The materials tested consisted of treated greensand "A," an artificial zeolite "B," a treated clay "C" and an artificial zeolite "D." The major part of the work, however, was carried out with the treated greensand (A).

Softening capacity of treated greensand "A"

These tests were carried out both on a laboratory scale and in domestic types of softeners.

a. Amount of salt required for the reconditioning of treated greensand "A." The purpose of these experiments was to ascertain not only the minimum amount of salt which would produce maximum reconditioning of "A," but also the most economical amount of salt to use. Laboratory tests were carried out using University of Iowa tap water, hardness as $CaCO_3$, about 26 grains per gallon, while the results with the domestic installations were obtained in Chicago, using Chicago city water (Lake Michigan water), which had an average hardness, as $CaCO_3$, of 7.65 grains per gallon.

For the laboratory tests one pound of treated greensand was placed in each of six 16-inch calcium chloride towers, the mineral being supported in each case by a layer of glass wool. Seven hundred cubic centimeter separatory funnels served as feed reservoirs for the filters, which were in turn fed from a large carboy (45 liters capacity) by a siphon.

For these tests regeneration was accomplished by adding salt, in dry condition, in varying amount to the different samples. The salt used was Morton's commercial barrel salt and contained appreciable quantities of magnesium and calcium chlorides. Water was then allowed to flow in until the towers were completely filled. The outlets were next opened and water allowed to pass through the filters at a slow rate (600 to 1000 cc. per hour) and tests were made upon the filtered water after the passage of each 100 cc. both for hardness and for chlorides. The amounts of zero hardness water obtained in each case were determined. From the series of tests, 20 grams of salt produced practically as much zero hardness water

as 25 and 30 grams in other filters, while the amount of zero hardness water rapidly increased as the amounts of salt were increased up to that point. Converted to pounds of salt required per pound of treated greensand "A," 20 grams represents 0.044 pound.

For the tests with domestic softeners, a softener containing 480 pounds of mineral was used. Dry salt was also placed in this softener and flushed through at a rate of about 4 gallons per square foot of filtering area per minute. The amounts of salt used varied from 2 to 20 pounds. Morton's salt was used for reconditioning and the source of water supply was Chicago city water. A study of table 1, representing a series of tests, shows that the most efficient amount of salt to use would be about 0.004 pound of salt per pound of mineral. One-half this amount of salt (1 pound) failed to produce any zero hardness softened water.

TABLE 1

Effect of varying amount of salt upon the capacity of treated greensand "A"

POUNDS SALT USED	GALLONS ZERO HARDNESS OBTAINED	GRAINS HARDNESS AS $CaCO_3$ REMOVED PER POUND MINERAL	POUNDS SALT PER POUND MINERAL
2	842	13.4	0.004
4	1030	16.4	0.008
8	1528	24.4	0.017
12	2012	31.9	0.025
16	2159	33.4	0.033
20	2200	35.1	0.042

Although a smaller amount of salt is more efficient, an amount of salt equal to 0.025 pound per pound of mineral is perhaps the most economical amount to use, since in using smaller amounts it would be necessary to recondition the plant more frequently, and the factor of time required for regeneration enters into the question, as well as the amount of water required for back-washing and reconditioning.

Having thus established the optimum amount of salt for reconditioning the material, 0.044 pound for the laboratory tests and 0.025 pound per pound of mineral in the domestic installations, the next work carried out was to determine the capacity of the material both on a laboratory scale and in the domestic installations under varying conditions.

b. Laboratory tests on the capacity of treated greensand "A." The laboratory filters previously described were used in these tests.

The first series of tests was made with University of Iowa tap water, and the regenerations were accomplished as in the preceding laboratory experiments. Later solutions of different degrees of hardness were used in place of tap water.

In the tests with tap water the rates of softening were varied through wide limits. The change did not appreciably affect the capacity of the filters. With constant rates there was a rather wide range in results, hence average results were taken for the capacity of the mineral. These variations may be accounted for by the fact that there was no provision made for back-washing the filters, hence when a channel was formed during a softening period there was no means of breaking it up.

At first sight it would appear that these results carried little meaning, but the variations may be satisfactorily explained by the fact that, all zeolites operate under the law of mass action. When channelling results there is residual replaceable sodium left in the filters, when they no longer deliver water of zero hardness, and a lowered capacity results. If the channels are broken up during the next regeneration practically the same exchange of bases takes place as if all the sodium had been replaced during the previous test, and the material thus contains more replaceable sodium and a higher capacity results.

These tests showed conclusively that the rate of passage of water through the mineral up to a certain rate did not have any effect upon the capacity realized. It also showed that the base-exchanging action of treated greensand "A" is almost instantaneous.

Another point established was that the same amount of wash water was required to free the mineral from hardness and chloride after reconditioning regardless of the rate of flow through the filters. In all cases zero hardness water was obtained before the chloride had been completely washed out.

With rates varying from 250 to 12,950 cc. per hour the average amount of hardness (as $CaCO_3$) removed in 51 tests was 33.2 grains per pound of mineral per regeneration accomplished by 0.044 pound of salt. The average amount of zero hardness water obtained from the tap water (average hardness 26.1 grains per gallon) was 4804 cc. while it required 520 cc. of water to completely wash out the hardness and 1040 cc. to wash out the chlorides after reconditioning.

The next series of tests was made to determine whether the treated greensand "A" had a different capacity for removing hardness when softening waters containing different amounts of hardening salts. These tests were carried out similarly to those using the University tap water, except that synthetic solutions of varying hardness (calcium) were substituted. Table 2 shows the results of these tests.

Since the above results showed such a wide variation, it was decided to devise a set of experiments which would provide a means for breaking up channels formed during filtration, and which would also serve the same purpose as backwashing. Two pounds of

TABLE 2

Capacity of treated greensand "A" for waters of different degrees of hardness under laboratory conditions

HARDNESS OF SOLUTION GRAINS PER GALLON AS $CaCO_3$	GRAINS PER GALLON HARDNESS REMOVED PER POUND MINERAL
5	32.8
10	35.2
15	41.0
20	34.7
25	29.2
30	36.1
Average	34.0

treated greensand "A" were placed in each of three glass tubes 24 inches long and $1\frac{3}{4}$ inches in diameter. One hole rubber stoppers with delivery tubes were placed in each end of the tubes. These served as the inlet and outlet for the solution passing through the mineral. The mineral was supported by glass wool. In these experiments an excess of salt (NaCl) was used for reconditioning. In reconditioning the salt solution was poured into the tubes and agitated in such a manner that all particles of the mineral came directly in contact with the salt solution. The salt was then washed out with distilled water until zero hardness was obtained. A 20 grain per gallon hardness ($CaCO_3$) solution of $CaCl_2$ was then passed through the filters. The average capacity for the tests was a removal of 38.84 grains of hardness per pound of mineral.

An interesting feature was the fact that some of these tests were made by softening upward while others were made by softening downward. The results are tabulated in table 3.

This set of experiments gave higher capacities than the calcium chloride tower experiments, which may largely be accounted for by the improved method of reconditioning in the latter set of experiments. An excess of salt was also used for reconditioning in these tests.

In conclusion it may be said that the average softening capacity of treated greensand "A" under laboratory conditions, when using an excess of salt, varies from 33 to 39 grains of hardness per pound of mineral.

TABLE 3

Capacity of treated greensand "A" when softening downward and upward under laboratory conditions

NUMBER OF EXPERIMENT	GRAIN GALLONS OF HARDNESS REMOVED PER POUND MINERAL			METHOD OF SOFTENING
	Tube 1	Tube 2	Tube 3	
1	42.5	33.8	39.4	Downward
2	37.9	41.6	42.3	Upward
3	40.6	38.0	34.4	Upward
4	40.0	36.2	34.8	Upward
5	36.7	45.6	41.3	Upward
Average.....	39.5	39.05	38.4	

While the laboratory tests have their faults and while there is considerable variation in the results, the data obtained are really worth while, but conclusions must not be drawn from one or two experiments. On the contrary, a large number of tests have been made and the results obtained represent an average capacity of the mineral, largely dependent upon the means used for breaking down the channels formed during the process of softening.

c. Capacity of treated greensand "A" as determined in domestic softeners of different types. The softening capacity of treated greensand "A," using varying amounts of salt, had already been determined in an installation containing 480 pounds of mineral (see table 1). The most economical amount of salt to use for reconditioning was established at 0.025 pound of salt per pound of mineral, and the results obtained with domestic softeners have been with this amount. In all cases regardless of the size of the softener, the dry

salt was added to the softeners and any lumps thoroughly pulverized to permit more rapid solution.

Besides the installation containing 480 pounds of mineral already referred to, additional types of softeners containing 100 pounds and 190 pounds of mineral were used. Chicago city water (Lake Michigan, hardness as $CaCO_3$, 7.65 grains per gallon) and synthetic solutions of varying strength of calcium chloride and magnesium sulfate were used in these tests. In addition to determining the softening capacity, these tests were also made with the view of determining, if possible, the effects of different rates of softening, backwashing, and reconditioning upon the softening capacity of the mineral.

1. Capacities when using three similar installations containing 100 pounds of treated greensand "A" mineral. When using Lake Michigan water, an average of 397 gallons of zero hardness was obtained from 13 tests on each softener. This figure is equivalent to a removal of 30.4 grain gallons per pound of mineral for each softening period. The results varied appreciably and bear out a previous statement regarding the effect of channeling. Somewhat greater capacities were obtained with higher rates of backwash, tending to show the value of a vigorous backwash in breaking up filtering channels. The rate of reconditioning had very little if any effect upon the capacity of the mineral. In other words, the exchange between sodium, and calcium and magnesium is practically instantaneous. Another set of experiments described later will show that with excessively high rates of softening the amounts of soft water are decreased, due no doubt to the packing of the mineral followed by channeling.

In these tests the average amount of water used for backwashing was about 28 gallons, while about 22 gallons were necessary for each reconditioning period.

The next sets of experiments were carried out using synthetic solutions. The water used for preparing these solutions was of zero hardness and was obtained by previously softening Lake Michigan water with a softener containing treated greensand "A." The water was run into a storage tank of 370 gallons capacity and solutions of calcium chloride were prepared which corresponded to a hardness (as $CaCO_3$) of 9.3 and 55.0 grains per gallon respectively. These solutions were allowed to flow by gravity to the softeners. In all cases Lake Michigan water was used for backwashing and reconditioning and,

when zero hardness water was obtained on reconditioning, the synthetic solutions were passed through the softeners to determine the softening capacities towards these solutions.

These tests showed some remarkable results. The average softening capacity, under the conditions, for the 9.3 grain water was 27.2 grain gallons per pound of mineral, while for the 55 grain water the average capacity was only 23.1. The poor results are accounted for as follows. In the first place, due to the lack of pressure, the water passed through the softener at extremely slow rates, which no doubt gave rise to channeling effects. Since the softening capacity for the harder water was much less it was evident that the depth of the bed of mineral was too shallow for good softening conditions, hence these softeners were discarded at this point and two larger softeners containing 190 pounds of mineral were used in their place. A centrifugal pump was also installed in the feed line to furnish sufficient pressure to insure a flow of water fast enough for good softening conditions. The pressure furnished was 38 pounds per square inch.

2. Capacities using two similar installations containing 190 pounds of treated greensand "A." These installations contained a depth of $18\frac{3}{4}$ inches of mineral supported by a bed of two sizes of gravel. For these tests synthetic solutions of both calcium chloride and magnesium sulfate were used. The solutions were prepared from the softened Lake Michigan water in the storage tank already described. The concentrations of the calcium chloride and magnesium sulfate solutions varied from 5 to 60 grains of hardness (as $CaCO_3$) per gallon.

Before these tests were carried out, several experiments were made using the Chicago city supply as the hard water supply. The average softening capacity in these tests was 30.8 grain gallons per pound of mineral. In the tests which followed, Lake water was used for both backwashing and reconditioning. An average of the results of these tests is given in table 4.

For both calcium and magnesium solutions, zero hardness water was obtained only for concentrations of 30 grains (as $CaCO_3$) per gallon or less. For concentrations between 40 and 60 grains small amounts of hardening salts were passed. The results are tabulated in table 5.

It is possible, had a deeper bed of mineral been used, that zero hardness water would have been obtained in these tests. Even a 60 grain hardness water was softened, however, to 1 grain gallon of hardness.

d. Discussion of the capacities of treated greensand "A." From a study of all the capacities of the mineral so far included in this report it will be noted that higher results have been obtained in the laboratory tests. This is largely due to the fact that an excess of salt has been used in all these tests over that used in the experiments for reconditioning the domestic installations.

TABLE 4

Capacity of treated greensand "A" for waters of different degrees of hardness when softening synthetic solutions

HARDNESS OF SOLUTION GRAINS PER GALLON AS $CaCO_3$	GRAIN GALLONS OF HARDNESS REMOVED PER POUND OF MINERAL FOR EACH SOFTENING PERIOD	
	$CaCl_2$ solution	$MgSO_4$ solution
5.0	30.1	
10.0	30.3	29.1
20.0	29.7	28.3
30.0	31.2	32.4
40.0	29.3	33.0
50.0	31.6	30.4
60.0	31.5	30.9
General average.....	30.5	30.7

TABLE 5

Degree of softening of extremely hard waters by treated greensand "A"

HARDNESS OF SOLUTION, GRAINS PER GALLON	HARDNESS AS GRAINS PER GALLON REMOVED ON SOFTENING PER POUND OF MINERAL	
	$CaCl_2$ solution	$MgSO_4$ solution
40.0	39.5	
41.3		41.0
50.0	49.0	49.5
60.0	59.0	59.25

In using 0.025 pound of salt per pound of mineral an average capacity of a little over 30 grains of hardness per pound of mineral was obtained under good conditions for domestic installations. Somewhat higher capacities may be obtained if larger amounts of salt are used for reconditioning.

These tests show that the exchange values for calcium and magnesium are the same, i.e., atom for atom. This is in accord with the findings of Hulbert (12) who found it different from Permutit

and Refinite which have higher capacities for calcium than for magnesium.

The rates of exchange with treated greensand "A" also appear to be about the same for calcium as for magnesium. A speed of softening with treated greensand "A" from 2 to 4½ gallons per square foot area per minute gives no appreciable differences in the amounts of soft water obtained for the softeners used in these investigations. It will be remembered, however, that extremely slow rates, i.e., under 1 gallon per square foot area per minute, gave lowered capacities in the installations containing 100 pounds of mineral. Excessively high rates also give a decreased capacity. When softening at a rate of 10

TABLE 6

Effect of alkali content of waters upon the softening capacity of treated greensand "A"

RATIO OF CALCIUM TO SODIUM BY WEIGHT		GRAINS HARDNESS (AS $CaCO_3$) REMOVED PER POUND OF MINERAL	PER CENT LOSS OF EFFICIENCY OF MINERAL
Calcium	Sodium		
1	0.0	38.6	
1	1.0	37.8	2.07
1	1.5	35.0	9.30
1	2.0	31.4	18.60
1	3.0	25.3	32.40
1	4.0	11.1	71.30

gallons per square foot area per minute in an installation containing 480 pounds of mineral, only 21½ grain gallons of hardness were removed per pound of mineral. The chief difference with excessively high rates is that the mineral packs too hard to get even distribution of the water passing through the bed and channeling results.

e. Effect of varying amounts of sodium salts in a constant hardness solution upon the capacity of treated greensand "A." A standard calcium chloride solution equivalent to 20 grains of hardness (as $CaCO_3$) per gallon was used, and laboratory tests were carried out in the tubes already described. The solutions were prepared by using chemically pure sodium chloride in varying quantities with a constant strength calcium chloride solution. An excess of salt was used in the regenerations. The results are tabulated in table 6.

As the alkali content of a water increases with respect to the hardening salts the efficiency of the softening properties of the mineral is decreased. For economical softening the ratio of the alkali

content to calcium must be low. Since the treated greensand "A" has the same capacity for magnesium salts that it has for calcium salts, the calcium-sodium ratios should be applicable to magnesium-sodium ratios. The above data bear out a previous statement that the base exchange of the zeolites follows the law of mass action.

TABLE 7

Average relative solubilities of zeolites in varying strength carbon dioxide solutions

Material dissolved in parts per million

	CARBON DIOXIDE P.P.M.			
	2	10	50	125
Treated greensand "A"	34	101	162	208
Treated clay "C"	41	65	99	150
Artificial zeolite "D"	111	240	280	286

TABLE 8

Average relative solubility per pound of zeolites in varying strength carbon dioxide solutions

Material dissolved in parts per million

	CARBON DIOXIDE P.P.M.			
	2	10	50	125
Treated greensand "A"	25	73	118	151
Treated clay "C"	52	82	124	188
Artificial zeolite "D"	178	384	448	458

GENERAL PROPERTIES OF ZEOLITIC WATER SOFTENERS

a. Effect of carbon dioxide upon different zeolites. These tests were carried out in the calcium chloride towers already described. Distilled water solutions containing varying quantities of carbon dioxide were passed through the zeolites at a constant rate and the soluble material determined by evaporating, drying and weighing. The relative solubility of equal volumes of the different zeolitic waters softeners tested are tabulated in table 7.

The solubility of all the zeolites tested increased with the carbon dioxide content of the water. Volume for volume "C" is the least soluble. The relative solubilities calculated weight for weight show "A" to be the least soluble (table 8).

b. Effect of mineral acids upon zeolitic water softeners. These tests were also carried out in the calcium chloride towers and varying strength solutions of hydrochloric acid were passed through the filters at uniform rates. The results are recorded in table 9.

The zeolites are all fairly soluble in hydrochloric acid, and the solubility increases with the concentration of the acid. All the residues were siliceous in nature. The reaction towards other mineral acids should be similar.

TABLE 9

Average relative solubilities per pound of zeolites in varying strength hydrochloric acid solutions

Material dissolved in parts per million

	HYDROCHLORIC ACID		
	0.001N	0.01N	0.1N
Treated greensand "A"	270	498	3,755
Treated clay "C"	634	811	5,897
Artificial zeolite "D"	490	926	7,827
Artificial zeolite "B"	726	1,390	10,256

TABLE 10

Average relative absorption of potassium hydroxide per pound of zeolite mineral

Material dissolved parts per million

	POTASSIUM HYDROXIDE		
	0.001N	0.01N	0.1N
Treated greensand "A"	7.3	−316	−1530
Treated clay "C"	55.2	−454	−4495
Artificial zeolite "D"	184.8	−302	−2938

Tests carried out showed that the zeolites would not soften water when an appreciable amount of acidity was present. The first tests gave a softened water, but after the alkalinity of the zeolites was neutralized their softening power was destroyed.

c. Effect of alkalies upon zeolitic water softeners. These tests were also carried out in the calcium chloride towers, and in the first series of tests varying strength solutions of potassium hydroxide were used. These tests showed conclusively that, up to a certain point, alkalies are absorbed by the zeolites, i.e. the residues determined after the solutions had passed the zeolites were less than those of the original solutions. The results are tabulated in table 10.

Continued tests showed that after a certain point the absorption became smaller and smaller. Volume for volume there is not much variation among the zeolites tested in their power to absorb alkalies, but weight for weight treated greensand "A" absorbs less than the others. The zeolites satisfactorily removed hardness from these solutions. The residue from the above tests were quite high in carbonates.

A second series of tests were made in which the alkali used was lime water (calcium hydroxide) in varying strengths. In the highest concentrations there was an absorption, while in the lower the residues were greater after passing. The results are tabulated in table 11.

TABLE 11

Average relative absorption of lime water per pound of zeolite mineral

Material dissolved parts per million

	CALCIUM HYDROXIDE		
	0.001N	0.01N	0.04N
Treated greensand "A"	199	52	−581
Treated clay "C"	424	190	−664
Artificial zeolite "D"	235	295	−18
Artificial zeolite "B"	499	212	−1168

These tests bear out the general conclusions derived above that the zeolites absorb alkali. This is especially true of caustic solutions of higher concentrations. In the above set of figures calcium has been exchanged for sodium which appears in the residue. These tests showed the other zeolites superior to "C" in softening caustic solutions. In the 0.04N $Ca(OH)_2$ solution all the zeolites furnished a zero hardness water except "C," which gave a water containing 7 grains of hardness. The original solution contained 120 grains of hardness. It is possible that "C" would have removed all the calcium had the rate been slow enough. In the other solutions "C" furnished a zero hardness water. It is shown, however, that "C" is not as rapid in its exchange action as artificial zeolites "B" and "D," both of which are much slower than treated greensand "A."

To prove definitely that there was an absorption of the hydroxyl (OH) radical, titrations were made before and after passing the caustic solutions through the zeolites with N/50 sulfuric acid, using

both phenolphthalein and methyl orange as indicators. In all cases where there was an absorption of alkali both the phenolphthalein and methyl orange alkalinities were greatly reduced when the solutions were passed through the filters. In the lower concentrations the phenolphthalein alkalinity decreased, but with artificial zeolites "B" and "D" the methyl orange alkalinity increased. This is due to the solution of the carbonates from the zeolites.

The absorption of alkalies by the zeolites appears to be largely an absorption of the whole molecule of the alkali, with an increasing hydration of the zeolitic grains. Volume for volume all the zeolites tested absorbed alkalies to about the same extent, but weight for weight treated greensand "A" absorbed the least.

d. Comparison of the calcium removed on regeneration to that adsorbed during softening when a 0.01N Ca $(OH)_2$ solution is softened. This series of experiments was carried out in the calcium chloride towers, equal volumes of fresh samples of "A," "B," "C" and "D" being used. The testing solution was 0.01N calcium hydroxide ($Ca(OH)_2$), two liters of which were passed through the filters. The water at the end of these periods in all cases was free from hardness. The zeolites were reconditioned with Morton's salt solution in such a manner as to correspond to actual operating conditions of each zeolite. After reconditioning, the zeolites were washed free from hardness and the calcium liberated determined. Correction was made for the calcium content of the salt solution. The ratio of the amount of calcium liberated on reconditioning to that adsorbed during the softening period is given in table 12.

Titrations of the alkalinity were also made on the original solution and the filtered samples to note whether there was any correlation of the amount of calcium adsorbed to the absorption of the hydroxyl (OH) ion.

These titrations showed that "A" at first adsorbed large quantities of causticity which were not liberated on reconditioning, and at the end of these tests the hydroxyl (OH) was still being adsorbed. This was also true with "B" and "C," but the ratios of the original phenolphthalein titrations to the methyl orange were somewhat changed. In the latter tests the methyl orange alkalinity of the water passed through "B" was greater than that of the original solution, showing the solution of carbonates from the mineral.

Titrations were also made upon the reconditioning solutions, and it was noted that caustic alkalinity was in all cases detected in the

water from "A," "B" and "C." Caustic alkalinity was not detected in all cases in the wash water of "D," due to the high solubility of the carbonates of the substance.

These experiments show that the minerals are not thoroughly hydrated and that they may easily become more highly hydrated by the action of caustic solutions.

In all the later tests it seemed that the zeolites had become adjusted to the action of the hydroxyl groups of the calcium hydroxide as their release was proportional to the adsorption. This was true

TABLE 12

Ratio of calcium removed on reconditioning to that absorbed when a 0.01N $Ca(OH)_2$ solution is softened

TEST NUMBER	CALCIUM (MGS.) ADSORBED PLUS Ca OF SALT	CALCIUM LIBERATED (MGS.) + Ca OF SALT			
		"A"	"D"	"C"	"B"
1	566.0	242.2	19.2	366.1	307.5
2	566.0	301.6	42.3	472.8	284.5
3	566.0	463.2	51.9	638.1	470.9
4	560.2	474.7	76.9	559.3	469.0
5	560.2	497.8	124.9	567.0	472.8
6	560.2	197.8	136.5	586.2	494.0
7	539.1	503.6	188.4	503.6	484.4
8	539.1	555.5	215.3	513.2	482.4
9	519.9	484.4	249.9	515.1	528.6
10	523.7	503.6	297.9	513.2	530.5
11	514.1	538.2	342.1	517.0	538.2
12	514.1	510.3	310.4	511.3	500.7
13	514.1	555.5	344.0	528.6	501.7

with "A," "B" and "C." Indications are that the same would have been true for "D" had the experiments been carried to that point. We may explain the fact that the release of the calcium from the zeolites was not quantitative at the start, as follows:

The zeolites contain carbonates. This is especially true of the artificial zeolite "D" tested in these experiments as it was a new sample. When the calcium hydroxide ($Ca(OH)_2$) comes in contact with the carbonate, for example, as sodium carbonate (Na_2CO_3) a precipitation of the calcium is effected according to the reaction—

$$Ca(OH)_2 + Na_2CO_3 \rightarrow 2NaOH + CaCO_3$$

The calcium thus precipitated is insoluble and does not really enter into the base exchange for sodium (Na) during softening. On regeneration the calcium carbonate ($CaCO_3$), not being appreciably soluble in the salt solution, is left as a precipitate.

TESTS ON THE SOLUBILITY OF CALCIUM CARBONATE IN 10 PER CENT SALT SOLUTION

Tests were carried out in an effort to determine whether the calcium carbonate thus precipitated would be soluble in the reconditioning solution.

TABLE 13

Sieve analysis of sand grains

	PER CENT RETAINED ON MESH		
	St. Louis	Columbus	Grand Rapids
20 mesh	0.0	99.9	62.2
40 mesh	86.5	0.1	37.6
60 mesh	13.2	0.0	0.1
80 mesh	0.1	0.0	0.0
100 mesh	0.0	0.0	0.0
Totals	99.8	100.0	99.9

Seidell (13) reports the following solubilities of $CaCO_3$-Water, contact with air dissolves 0.065 gram $CaCO_3$ per liter at 20°C., 10 per cent NaCl contact with air dissolves 0.134 gram $CaCO_3$ per liter at 25°C. Water, free from CO_2 in contact with air, dissolves 0.0128 gram per liter at 18°C.

It would seem, therefore, that the solubility in the reconditioning solution (10 per cent NaCl) of any $CaCO_3$ precipitated on the particles of the zeolites might play an important part in the softening process. With this idea in view tests were carried out upon filter sands coated with $CaCO_3$. These sands had been used after lime-alum or lime-iron coagulations and were typical "growing sand grains." A sieve analysis of the sands gave the following composition.

Equal volumes (400 cc.) of these sands were placed in the calcium chloride towers already described. The resulting weights were: St. Louis sample, 510 grams; Columbus, 552 grams; Grand Rapids, 539 grams. The salt solution used was a 10 per cent salt solution

of commercial salt (Morton's) which contained appreciable amounts of calcium chloride.

The tests were carried out in a manner which would be comparable to reconditioning water softening plants: (*a*) By allowing the salt solution to trickle through the filters, which would correspond to the period of reconditioning of treated greensand "A" and (*b*) allowing the salt solution to stand in contact with the sand grains six to nine hours which would correspond to the period of reconditioning of artificial zeolites "B" and "D" and treated clay "C." The results are given in table 14.

These tests showed a slight solubility of $CaCO_3$ with the St. Louis sample (the finest) except in the case where the contact was

TABLE 14

Solubility of $CaCO_3$ in 10 per cent commercial salt solution

Milligrams Ca per 100 cc. solution

TIME OF CONTACT	Ca CONTENT SALT SOLUTION	SALT SOLUTION AFTER PASSING		
		St. Louis sand	Cleveland sand	Grand Rapids sand
18 minutes	48.4	51.0	46.5	49.7
18 minutes	48.4	50.5	49.0	49.6
6 hours	48.4	56.4	40.4	38.8
6 hours	48.4	49.0	31.0	34.6
9 hours	48.4	47.0	30.5	29.9

9 hours. The coarser sands showed a very slight solubility of the $CaCO_3$ when they were in contact with the salt solution for only eighteen minutes, but upon standing they adsorbed calcium from the salt solution.

These tests show that, where there is enough surface exposed, any $CaCO_3$ precipitated on the zeolitic surfaces would tend to go into solution when treated with 10 per cent commercial salt solution. The solubility is not a function of time, if the salt contains appreciable quantities of calcium. When left in contact with the minerals for a longer time the surfaces may actually keep on adsorbing calcium, the amount of calcium adsorbed being a function of the size of the zeolite grains.

These tests show the need of exercising care in presoftening with lime alone or lime-soda if the water is to be treated with a zeolitic filter.

SUMMARY

Treated greensand "A" is a rapid rate water softening material. The regeneration and softening base exchange of this mineral is practically instantaneous, and rates of softening as high as 4 or 5 gallons per square foot area per minute do not lower its softening capacity. Excessively high rates produce packing of the mineral and channeling results, giving lowered capacities. A certain amount of water pressure is also essential for good softening results. For good softening results a vigorous backwash should be used to break up channels and to remove collected sediment.

A removal of thirty grains of hardness (as $CaCO_3$) per pound of mineral can be expected in domestic installations when softening to zero hardness, if 0.025 pound of salt is used per pound of mineral for reconditioning. Lower amounts of salt are more efficient but 0.025 pound seems the most economical amount to use when all conditions are considered.

The exchange value for calcium and magnesium is the same for treated greensand "A." Other zeolites differ in this respect.

The softening capacity of treated greensand "A" is directly dependent upon the relative concentrations of the hardening salts to the sodium salts of the water being softened; the greater the ratio of the sodium to the hardening salts, the lower the capacity of the mineral.

Both the softening and reconditioning reactions of zeolite water softeners follow the law of mass action. The extremely fast reaction of treated greensand "A" shows the reaction to be largely an adsorptive phenomenon, the reaction being almost entirely on the surface of the grains, while the slower reactions of other zeolites show the reaction to be a combination of both adsorption and absorption. In all cases the reactions are to be considered chemical equilibrium reactions.

The base exchange of zeolite water softeners takes place only in neutral or alkaline solutions.

The solubility of all the common zeolitic water softeners increases in water with increasing carbon dioxide content. The solubility of the natural zeolites is less than the artificially prepared substances.

The zeolites are quite insoluble in alkalies and are rapidly hydrated by their presence. All the common softeners will satisfactorily soften caustic alkaline waters.

It is possible that the softening power of the zeolites is a direct function of their state of hydration, hence reconditioning with caustic alkali gives higher capacities than treatment with alkali chlorides.

The calcium from lime alone or lime-soda pre-softened waters may be quantitatively displaced from zeolitic softeners upon reconditioning, provided such softened waters are thoroughly clarified when passed through them. If the waters are not thoroughly clarified, calcium carbonate may form on the zeolitic grains and impair their action.

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WATER SOFTENING DEMONSTRATION[1]

By Charles P. Hoover[2]

In accordance with Mr. Gwinn's wishes, I am not to present or read a paper, but I am to make a beaker and cylinder exhibition in order to illustrate the lime-soda-ash method of softening water.

The minerals present in water giving it its hardness, are:

1. $CaCO_3CO_2$—calcium carbonate, ordinarily known as limestone.
2. $MgCO_3CO_2$—magnesium carbonate, ordinarily known as magnesite.
3. $CaSO_4$—calcium sulphate, ordinarily known as gypsum.
4. $MgSO_4$—magnesium sulphate, ordinarily known as epsom salts.

Calcium and magnesium carbonates in the water constitute what is known as temporary hardness. These two salts are held in solution by carbon dioxide or carbonic acid, and may be precipitated from the water by the addition of lime, because lime combines with and absorbs the carbonic acid, and, as soon as this acid is eliminated from the water, the carbonates are precipitated. These carbonates can also be precipitated from the water by boiling it. All of you have observed, no doubt, that, when hard water is boiled in a kettle, there is always a mineral deposit in the bottom of the kettle in which the water is boiled, and this mineral is deposited because the carbonic acid has been driven out of the water by the heat.

A few drops of phenolphthalein indicator solution added to water will show the presence or absence of free carbonic acid. You will see that, when I add phenolphthalein indicator to this sample of raw water, there is nothing to indicate that anything has happened, but when I add the same amount to this sample of lime softened water, the sample immediately turns to this beautiful reddish pink color. The results show that the raw river water contains carbonic acid but that the lime treated water does not, and the results are

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] Chemist-in-Charge, Water Softening and Purification Works, Columbus, Ohio.

indicated by the absence or presence of the red color on the addition of the indicator.

Now I will blow, through a tube, into this sample of softened water, colored red by the indicator, and you will see that it immediately loses its color, because in breathing or blowing, I have exhaled carbonic acid which has been absorbed by the water, or, in other words, the water has been recharged with carbonic acid.

If now I take a piece of limestone, which is insoluble in pure water, and crush it into a fine powder and sprinkle it into this carbonated water, it will dissolve because carbonic acid is a solvent for it, and it will stay in solution unless the carbonic acid is gotten rid of.

In order to remove limestone or calcium carbonate from the water, it is necessary, as I have already stated, to absorb or drive off the carbonic acid, and you will see in this next experiment that, when lime is added to the water which I have just carbonated, the red color returns, proving that the carbonic acid has been absorbed.

In commenting on the hardness of water, it is often spoken of as containing lime salts, the presence of these lime salts being the cause of the hardness. In order to understand what takes place in water softening, it is necessary to know the difference between the so-called lime salts (calcium carbonate usually being meant) and lime. Lime is made by burning calcium carbonate or limestone in a kiln. If, for instance, 100 pounds of calcium carbonate or limestone are burned in a kiln, there will be produced 56 pounds of lime and 44 pounds of carbonic acid gas, which goes up the stack of the kiln.

$CaCO_3$	+	Burning	=	CaO	+	CO_2
Limestone				Lime		Carbon dioxide

Now, many chemical reactions are reversible and we have an example of this in the production of lime from limestone. If, as I have already said, calcium carbonate is burned, calcium oxide or lime is formed, whereas, on the other hand, if lime is allowed to cool and is exposed to carbonic acid (ordinary air contains carbonic acid), it reverts back to limestone. Advantage is taken of this reaction in ordinary house plastering. Soft lime plaster is put on the wall, and it gradually becomes hard because, by absorbing carbonic acid from the air, it is converted into or reverts back to limestone, the material from which it was originally made.

In softening water, in order to know how much lime is required, the amount of carbonic acid present in the water must first be deter-

mined. We have already shown that 100 pounds of limestone, when burned, produces 56 pounds of lime and 44 pounds of carbonic acid, and that the reactions taking place in this process are reversible. Therefore, if the results of the water analysis show that 1000 gallons contain, say, 44 pounds of carbonic acid, dissolved, then it would be necessary to add 56 pounds of lime to the 1000 gallons, and this 56 pounds of lime, combining with the 44 pounds of carbonic acid converts it into 100 pounds of insoluble calcium carbonate, which is easily removed from the water, and thus we now see what has happened to the lime itself.

The effect of the lime is to absorb the carbonic acid, and the carbonic acid having been absorbed, the carbonates held in solution by this acid are immediately precipitated and removed, so that, as a result of this treatment, there is in reality nothing added to the water. I want to emphasize this point, because you are aware of the fact that, whenever any municipality undertakes a project to soften or purify its water supply, and the people find out that chemicals are to be used in its treatment, they are immediately opposed to it, because they are afraid that the water will be doped with chemicals or something added that will be injurious to their health. The softening process introduces nothing into the water, nor does it take anything away from the water that will injure the health or comfort of the consumer, softened water being very palatable.

A Columbus physician advised me recently to boil the city water before giving it to our infant child, then remembering my connection with the water department, assured me that he did not mean to infer that the water was not safe from a bacterial standpoint, but reminded me that boiling precipitated the lime salts. Later on, I was advised to add a tablespoon full of saturated lime water to each feeding of milk. A number of gallons of water would be required to furnish the equivalent amount of lime. An analysis of the milk, without the addition of lime, showed that it contained 54 times as much calcium as the city water, so that this evidence is rather convincing that water was not intended as a source of supply for mineral constituents needed by the human body.

The lime treatment removes that part of the hardness known as temporary hardness, but to remove the permanent or incrustant hardness, soda-ash is needed. The cost of removing incrustant hardness, or the cost of soda-ash treatment, is about three times that of lime treatment. Therefore, the cost of softening water depends

not only on its total hardness, but also on how much of the hardness can be removed with lime and how much must be removed with soda-ash.

Why are not all hard municipal water supplies softened? The answer would very likely be (1) on account of the cost, and (2) the fear of deposits of carbonates in the distribution system, meters and hot water systems. These two reasons for not softening a hard municipal water supply are really the only two that I know of that merit consideration.

The saving in soap alone to a community will pay for all costs of softening and in addition to that there will be saved the losses due to extra expense of cisterns and double plumbing systems, losses in hot water heaters and boilers. Recarbonation of the softened water will prevent the formation of deposits in meters and distribution systems so that these reasons are not real objections.

Experiments on carbonation with carbon dioxide gas have been studied in an experimental way during the past year at the Columbus, Ohio, plant. The first experimental plant consisted of carbon dioxide gas in cylinders, applied to the water by means of an Electro Bleaching Gas Company chlorinator. The second plant consisted of a burner for burning coke, a blower sucking the gases from the burning coke and forcing them into an absorber. The third scheme tried out consists in sucking flue gases from the boiler stack of the pumping station, passing these gases through a scrubber and dryer and diffusing the gases into the water to be carbonated through a filtros plate diffuser or a diffuser made with twelve parts of coarse sand and one part of cement.

The question is often raised, "What is the practical limit for water softening in municipal practise?" It depends (1) upon the hardness of the raw water treated, and especially upon the amount of magnesium carbonate present; (2) upon whether or not excess lime and soda-ash treatment is resorted to; and (3) upon the temperature of the water being softened, temperature being a much more important factor than the time of reaction.

At Columbus, Ohio, during the cold winter months, the river water is fortunately highly diluted with flood water, causing the water at this season of the year to be at the lowest hardness. However, it sometimes happens that cold weather precedes the winter rains and it is right at this period when the river water is at its maximum hardness. It has been experienced at the Columbus plant,

that, with the hardness of the river water around 450 parts per million and with low temperature, the practical limit for water softening is about 125 parts per million. With the hardness of the raw water around 350 parts per million, it seems practicable to reduce the hardness to about 100 parts per million. On account of the expense involved, the permanent hardness or incrustant hardness is usually not reduced to less than 40 parts per million. If, however, the entire water supply were to be used exclusively for boiler feed purposes or for laundry work, it would then be practicable to add enough soda-ash to remove all the permanent hardness, and by resorting to excess lime treatment, then neutralizing the excess lime with soda-ash, a water with almost any hardness can be reduced to about 30 parts per million, or about 2 grains per gallon.

Columbus consumers are pleased with a water having a hardness of 85 parts per million, fairly well satisfied with a water having a hardness of 100 parts per million, but complain when the hardness of the water is up around 120 to 125 parts per million.

DISCUSSION

Dow R. Gwinn: I should very much like to have Mr. Hoover tell us about the Plant at Defiance, Ohio, the method used there for adding carbon dioxide to the water.

Charles P. Hoover: You may perhaps be interested to know that Nicholas Hill, who built the water softening and purification plant at Defiance, Ohio, is going to read a paper this afternoon before the Chemical and Bacteriological Section, discussing this plant. I have seen the Defiance plant in operation several times, and briefly the plant is operated as follows: The water is treated with lime, soda-ash and alum, passed through baffled mixing tanks, then allowed to settle for about four hours time, after which it passes through a rectangular shaped basin, which is provided with a false bottom, composed of filtros plates. As the water passes through this basin, carbon dioxide gas, produced by burning coke in a brick furnace, is introduced into the basin under the filtros plates, and the small bubbles of gas coming through the filtros plates are absorbed by the water.

Dow R. Gwinn: Has the application of the carbon dioxide to the water any other advantages?

CHARLES P. HOOVER: Mr. Campion, Superintendent of Water Works at Defiance, Ohio, reported at the last meeting of the Ohio Conference on Water Purification, that, under ordinary operating conditions, the water leaving the carbonation chamber has at all times a better and more distinct floc than the water entering. This condition may be due to the agitation by blowing the gas into the water; or, as has been suggested, there may be some unsolved reactions taking place which improve the floc. Dissolved oxygen tests have shown a slightly increased percentage of saturation in the water after having passed through this basin.

Perhaps an ideal method of producing carbon dioxide gas at a large water softening plant would be to burn limestone and use the lime for water softening purposes and then use the carbon dioxide gases for carbonation.

OSCAR E. BULKELEY: Is Mr. Hoover quite certain that this colloidal matter will be removed with carbon dioxide treatment; in other words, has the fact been established that this treatment will accomplish what it is intended to do?

CHARLES P. HOOVER: The Defiance Plant is the only plant that I know of that is now carbonating its entire water supply, and Mr. Campion reported at the Ohio Conference on Water Purification that after fifteen months of operation the sand in the filters appeared to be unchanged as far as deposits were concerned and that no trouble had been experienced from deposits in the meters or in the distribution system. From a chemical standpoint, it is hardly conceivable that any deposition difficulties should occur following carbonation, because after the water is carbonated, there should be no difference between it and thousands of raw water supplies that never have been softened.

ROYAL S. BUZZELL: I should like to ask Mr. Hoover if he has noticed any improvement in the taste of the water after re-carbonating? We have softened the city water supply at Flint, Michigan, for a considerable time. The water is similar in mineral content to the Columbus supply but, when softened with lime, a flat taste sometimes results, which is the cause of complaint by the consumers. A palatable taste is of course demanded and we endeavor to avoid or eliminate any disagreeable taste in the water. We have tried, in

an experimental way, aerating, also re-carbonating after softening and the results have been favorable, eliminating the flat taste and reducing the phenol alkalinity.

CHARLES P. HOOVER: The City of Lansing, Michigan, has recently built and put into operation a small demonstration water softening plant. At this plant there is provided a drinking fountain supplied with softened water, and right alongside is another drinking fountain supplied with unsoftened water. The visitors come to the plant and drink from both fountains and then are asked to tell which is which. Mr. Bulkeley, Superintendent of Water Works at Lansing, Michigan, is in the audience and I should like to have him tell the results of his experiments with the people of Lansing, and the effect of softening, if any, on the taste of water. For a short period of time softened, uncarbonated water was pumped, and later this was followed by softened carbonated water. I should also like to ask him if there was any difference noticed in the water after carbonation.

OSCAR E. BULKELEY: It is very difficult to detect any difference in the taste. Lansing has a hard artesian well water which will be used for a number of years to come, as its water supply. The hardness is approximately 350 parts per million. Our engineers propose to reduce this hardness to at least 100 parts per million and probably to 85 parts. A demonstration plant of 10,000 gallons per twenty-four hour capacity, complete in every detail, has been erected, and our people have been invited to come over and taste the water. A heater is provided so that hot water is available for washing. Two wash basins are provided; one for hard water and the other for soft water; two drinking fountains are also placed side by side, but the public is not informed as to which is soft and which is hard water. The attendant asks each visitor to tell which he thinks is soft water and a record is being kept. Before the demonstration began the members of the Water Board felt quite certain that it would be easy to distinguish the difference in taste, but they found it quite difficult actually to determine which was soft and which was hard water.

THE PARK RIDGE PUMPING STATION[1]

By W. T. McClenehan[2]

Anyone at all familiar with the water works game knows that a pumping station is always being remodeled, always changed. Pumps wear out; they become antiquated because of improvements in pump manufacture and they are supplemented by new and larger pumps added because of the city's increased population.

In spite of this constant change men in charge of pumping stations frequently do not realize the value of a well defined plan or program for making future additions to their pumping stations. They have adopted a "sufficient unto the day is the evil thereof" policy and improvements are made because of some immediate necessity forced suddenly upon them. As a result of this indifference many pumping stations have become a patchwork of machinery, pipe and buildings, often poorly related one part to another and sometimes curiosities wonderful to behold. The administration which adopts such a policy is not always to be blamed for its indifference for the men that make it up may be ignorant of the real engineering requirements. In such cases it becomes the duty of the engineer to make the administration see the real value of a well thought out plan for making additions.

In addition to adopting a plan for making improvements a city should occasionally take stock of the improvements it already possesses in the way of machinery, pipe, buildings, etc., to see whether they cannot be better arranged for pumping purposes. A study of this kind is especially advantageous where new equipment or new pumps are about to be added. The saving in friction and power may be considerable and the re-arrangement generally makes for a better looking, more convenient station.

The mayor and city council of Park Ridge, Ill., fully realized that their pumping station had been outgrown and that it needed remodelling. They therefore employed the firm of Pearse, Greeley

[1] Presented before the Illinois Section meeting, March 29, 1922.

[2] Assistant Engineer, Pearse, Greeley & Hansen, Chicago, Ill.

& Hansen last December to study the future requirements of the city and to make plans for improvements needed in the pumping station.

Originally the pumping station consisted of a well drilled into the Potsdam sand stone, an electrically driven deep well pump and a 6-inch main laid in the pump room floor to a standpipe built just west of the pump house. Off of this water main in the pump room floor were taken two 6-inch connections to the city; one leading south to a line in Center Street and one north to a line in Park Avenue. Valves were placed on these three lines, which were exposed in the pump room. No meter was included. It will be seen from this description that the arrangement of the original pumping station was not so bad at the time it was built. However, it was not long before changes were made which upset the arrangement. The standpipe was replaced by an elevated tank involving two connections to the mains in the pump house and providing a new connection to the line in Center Street. A new well was drilled in a southwest room built under the sidewalk on Center Street and connections made thereto. A 12-inch line was laid from the Chicago water system at the City limits and three different connections were made to the Park Ridge mains inside the pump house and one outside. About this time the original well was abandoned. Recently an air lift system was partly installed in the newer well to supplement the water supply received from Chicago in hot weather when the demand in Park Ridge exceeded the amount of water the City of Chicago was willing to sell.

Two centrifugal pumps were bought and one temporarily installed to boost the pressure when the Chicago pressure is low. The intention was to arrange the pumps to take water from the well reservoir also, but this work was never completed.

Such therefore was the situation at the plant when we took hold of it last December. There were no less than 11 different pipe connections to various mains inside the pump house and around the elevated tank. Most of the confusion was caused by the natural growth of the plant, but some of it was caused by incompleted construction. Even the pumper did not know where all the lines were. In fact, he scarcely knew the function of all the valves he had to handle.

Our first work was to locate accurately all valves, pipe lines, etc., inside and outside the building and to obtain the characteristics of

the pumps, motors and air compressor. From a study of the city's past increase in population and from a record of water purchases from Chicago over a period of several months, we estimated that by 1935 the population would be about 6000 and that the maximum twelve hour consumption would be about 1.5 million gallons per twenty-four hours. For short periods during the twelve hours this rate would be exceeded, but the tank we figured would supply the excess consumption. In addition it was estimated that the probable fire demand in 1935 would be about 3 million gallons per twenty-four hours.

The two centrifugal pumps had a combined capacity of around 2 million gallons so that it seemed likely that another pump would be required in the near future. Pipe lines were based on the requirements estimated for 1950 because of the greater life of the pipe. This rate was about 5 million gallons per twenty-four hours.

The problem of a layout was somewhat complicated by the awkward shape of the building which was shaped like a flat iron with but few parallel or right angle walls. In the layout selected, a 12-inch suction line is placed along the south wall on the floor connecting at one end to the Chicago main outside the building and extending into the well reservoir at the other end. Each end of this line will be valved for drawing water from either source of supply. Above the suction line will be placed the discharge header with a valved cross connection between it and the suction line. A venturi meter is to be installed in the discharge line inside the pump house, leaving room for the cutting in of another pump when that pump becomes necessary. The water will be discharged toward the west toward the elevated tank, although the city is largely to the east of the pumps. The reason for this is that existing piping could be utilized to better advantage and that all water could be metered. Besides the largest flow at most times is likely to be into the tank.

Some re-arrangement of the outside piping was found necessary. The most important change is the addition of about 90 feet of 8-inch pipe line to be laid to connect to an important point of intersection. A hydraulically operated valve was placed in a pit outside the pump house at the base of the elevated tank. The operating cock of this valve was placed inside the pump house on a post so as to be easily reached by the pumper in case of fire.

The pumps were so arranged that they would work either in parallel or in series, the change being accomplished by opening or closing one valve.

The switchboard is to be placed on a concrete platform at the level of the street above the pipe lines. The board was a part of a former purchase of pumps and motor equipment and is very good indeed. It has provision on it for no voltage and overload release and is made for push button and for automatic operation using a pressure gage.

We have arranged to place the push button stations on the same post as is placed the cock which operates the hydraulic valve.

The air lift system is being somewhat rearranged and completed so that the well which has been fitted up with the well head can be used this summer. By this arrangement the Engineer can do the following things without leaving the pump room.

1. Draw water from Chicago without pumping.
2. Draw water from Chicago using either or both pumps in parallel or in series.
3. Draw water from the well reservoir using either or both pumps in parallel or in series.
4. Operate the hydraulic valve.
5. Operate the air lift system.

Some old piping in the floor of the pump room can be utilized to discharge into the well reservoir whenever the older well is fitted up for use, which will be whenever the present supplies prove inadequate.

The only new machinery bought is a small vacuum pump to prime the centrifugals when it is necessary to pump from the reservoir.

The cost of the entire work is about $6600 including the building and manhole construction. While this layout is not ideal in every respect, it shows what can be done to an existing pumping station at very small cost utilizing existing equipment so as to make the whole station more serviceable, more workable and better looking.

USE OF HYDRANTS FOR PURPOSES OTHER THAN EXTINGUISHING FIRES[1]

By John W. Toyne[2]

With very few exceptions, every city has at some time been a village without the modern convenience, or more correctly, without the necessity, of a water utility, a condition where every one had his own well and the village maintained the "town pump," where any or all of the inhabitants were welcome at any time and the only cost was working the pump handle. Of course, there were repairs to be made occasionally, but Bill Smith from the hardware store and Si Jones from the implement shop would help the Marshalls put on the new leathers or put in some new poles, and even though it had been out of service for a few days, or weeks, no one was seriously inconvenienced, and no real damage had accrued through the mishap. This was the epoch of the "Bucket Brigade." Eventually, the next stage was reached when the "town pump" supply was augmented by the installation of fire wells, or cisterns, at what was assumed to be advantageous locations and the wet mop and bucket brigade supplemented, if not entirely replaced, by our new fire engine, manned by a volunteer force and operated through the thrilling hours of the fire by the application of man-power to the hand brakes of the wheezy old pump.

Finally a water works system was built, the fire hydrant replaced the cisterns, hose carts replaced the pump and a central pumping station became responsible for the supply and pressure.

Our village had become a town of some consequence and was, through the acquisition of industries, developing both in population and modern civic requirements. Sewers, pavements, curb and walks, buildings and various other enterprises arose that required water service of a temporary nature, all unquestionably for the betterment of the community as a whole, not only in the matter of appearance, but as regards sanitation and public welfare.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] Engineer, South Bend, Indiana.

It was but the outgrowth of the common use of the "town pump" that directed the use of its successor, the public fire hydrant, as the general temporary water service medium. It is not surprising that this use of the fire hydrant became universal, especially in municipally owned water utilities.

So universal is this practice, that I have failed to find a single municipally owned plant, and very few privately owned plants, where service is not rendered, either voluntarily or otherwise.

Within the past month, I was in a small city in northern Indiana, and was informed that no service was permitted from the fire hydrants. In less than an hour I counted a building contractor, a crew cleaning sewers, a teamster watering his team in a tub and a tank wagon filling from the fire hydrant. In two of the cases, Stillson wrenches were being used to operate the hydrants with the usual results. I noted where a number of other hydrants had experienced the same treatment.

I have talked with a number of city officials relative to this practice and I have been surprised at the lack of thought that has been given the two most essential elements entering into the consideration of this abuse of one of the most necessary pieces of fire fighting equipment, cost and reliability.

Thousands of dollars are appropriated for the purpose of fire fighting apparatus—pumpers, hose wagons, deluge sets, aerials, in fact everything that the ingenuity of man can conceive that will tend to assist the firemen in their work of fighting fire. Surely the administrators of our municipal government would be subject to severe criticism if they failed in their duty in this respect. At the same time, permission will be granted to almost any one, desiring water for almost any purpose, to use a fire hydrant, notwithstanding the fact that the hydrant is not designed as a service connection and that its use as such not only builds up an exorbitant maintenance cost but reduces the available fire protection.

This latter statement is not merely assumption based on the law of averages, but is fact, proven by actual conditions that have come under my observation. No doubt parallel cases have come within the experience of almost every one connected with water utility or fire protection work. I will cite one or two instances, not that they are unique or novel in any way, but because they are pertinent to the subject under discussion. A fire alarm was answered in an addition where the streets were badly cut up through

sewer construction. The hydrant that should have been used was tied up with a service line, without even a union and by the time the hose wagon had backed out to another hydrant, the house had burned down. At a hydrant ordinarily used by the street sprinkler for filling purposes, and on which the side cap was usually left open, a handful of small rock was discharged into the fire hose plugging the nozzle and allowing a roof fire, started from an adjacent fire, to gain considerable headway before the hydrant could be closed, the nozzle removed and another substituted. Small boys were severely criticized for dropping the rock into the hydrant, but as I see it, the criticism was directed at the wrong place entirely.

It would be difficult to estimate the cost in property damage and loss of life that has accrued from this practice and that is continuing as one of our disgraces.

When I was asked to "discuss" this subject, the first thought I had was, that it would be much easier to "just cuss it" and the farther I go, the easier it seems.

Really there are no arguments in favor of it. The only question open is, how long will it take the citizens of our communities to wake up to the fact that their lives and properties are being placed under an unnecessary hazard and compel us to stop it.

DISCUSSION

Dow R. Gwinn: It is largely a matter of education and keeping at it to reduce the number of uses for fire hydrants other than for fire fighting purposes. I went through it all. When I went to Terre Haute, I found they had a practice there of giving a contractor a nice little card that looked like a railroad pass, by which he was given permission to use water from the fire hydrants and the amount of the material that he used the water on would be reported at the end of the year. Then I found that the street sprinkler was using the hydrants. I saw one night where he had opened the fire hydrant to fill his tank, and about a week after that there was a fire almost in front of that hydrant and the fire department went there and got everything all fixed, ladders up to the attic window and yelled to the man at the hydrant to turn on the water, but he could not do it because the street sprinkler had used a Stillson wrench on the nut so often that it had rounded off the corners and the fireman could not open it. The result was that the roof burned off the house. Then I started in and tried to put a stop to the practice.

It was not easy. But if the city wants water for flushing a sewer, they call up the water works office and say, "Will you send out the controlling valve on 24th Street and Wabash Avenue?" "Yes, when do you want it?" "Right away." So we will put a man with the controlling valve and hydrant wrench on a bicycle and he goes out and screws the controlling or auxiliary valve on one of the nozzles; then he opens up the hydrant and the city folks use their auxiliary valve instead of using the main valve on the hydrant. When they get through, we go out and shut down the hydrant, take off the controlling valve and examine the hydrant and see that it is in good order. Whenever we have a fire we send one of the men out with a special order slip printed for that purpose and he goes out and examines all the hydrants used by the fire department, to see that they are left in good order, and he makes a written report on each one. A circus comes to town. You might ask, what do we do for him? We make a contract with him for $18 a day, including the time of a man who goes out with the hose and the controlling valve and stays there and watches that hydrant until the circus is through with it. In the meantime, we have the circus man pay the $18 in advance so we are sure of getting the money.

F. M. McElroy: There has been a good deal of discussion about the use of fire hydrants at the conventions I have attended in the past, and we are still discussing them. I do not believe it is possible for a city to prohibit absolutely the use of fire hydrants. I think the larger we grow, the more that becomes impossible. In our community we allow the use of fire hydrants, but it must be under the absolute control of the water department. The application is made at the office for the use of the fire hydrant, the permit is issued and the hydrant is equipped with a hydrant valve and the water turned on to the hydrant so there is no necessity for the main operating valve of the hydrant being used by some one not familiar with it. We have only been able to accomplish this in Racine in the last few years. I came to Racine some twelve or thirteen years ago and at that time the hydrants were being used promiscuously by almost any one. I insisted on the proper use of the hydrants, because I think there are times in the community when it is absolutely necessary that a fire hydrant be used. In Racine we sprinkle the streets from fire hydrants, with the placing of this auxiliary controlling valve on the hydrants. Contractors are required to

come to the water office for permit and we equip the hydrant. It was necessary for me to arrest a local contractor, and in Racine I have a collection of wrenches from fire hydrants made of saw blades, monkey wrenches, Stillson wrenches and numerous other devices that have been used on fire hydrants. I found the top nuts all rounded off where these various devices had been used, and it was necessary to arrest the guilty party or parties and it cost them $25 to $50 for using hydrants in this manner. I can state today that there is nobody using fire hydrants in Racine unless we know it. I know it is possible with a little effort to educate the consumer of this class to require him to get permits and use the fire hydrants in a proper manner.

My friend talks about the circuses. In my town a circus has to pay $25; the circus man may talk his head off about it, but it will cost him $25 with a man from seven in the morning until five in the afternoon for the use of a hydrant, and anyone else who uses a fire hydrant must get their permit and pay the charges. I find it is possible to control the use of fire hydrants. I think that may be a little more difficult in a larger city, but I believe that the water department should still continue to control the fire hydrants. We have a fully equipped, motorized fire department, costing thousands of dollars, and it does seem to me that the entire equipment is useless in small communities, if we are going to let the fire hydrants get away from our control, and this in part is true in the larger cities. In our community spacings of fire hydrants are very close, and if there should be a hydrant out of order, it does not make very much difference. Nevertheless, we have not had that happen, but in places where the hydrants are farther apart in spacing, I think the hydrants should be under the control of the water department to be sure they are in working order at all times. This cannot be done unless you know how the hydrants are being used.

W. S. Cramer: Have you ever tried putting the responsibility up to the fire chief and making the hydrants part of his fire fighting equipment and not to be used for any other purpose?

F. M. McElroy: We have never tried this and I am of the opinion that this is a matter of local conditions. There may be a great deal of merit in this at some places and it may be possible to do it, but I question it in any of the communities in which I have served. I believe it is the water department's duty to maintain the fire hydrants.

W. S. CRAMER: You have to get a chief that will work with you and one with backbone enough to assert himself.

W. S. MCELROY: The fire chiefs in the various cities in which I have had charge of the water department have coöperated with the water department and have done everything they could.

W. S. CRAMER: Of course the first step to avoid the use of fire hydrants for other than fire purposes is for your street department to put in their own standpipes for their own supplies. If you let them use them indiscriminately, you might as well let everyone else use them.

JOHN CHAMBERS: The Louisville Water Company has no control over fire hydrants. They are owned by the city and are under the supervision of the Board of Public Safety. If any one other than the city itself wishes to use water from fire hydrants he must pay the water company for the water consumed, but he must first secure a permit from the Board of Public Safety. If water is obtained from a fire hydrant for building purposes it is paid for on the basis of the number of cubic feet of concrete or other masonry. Hydrants are installed by contracts by the Board of Public Works on recommendation by the Board of Public Safety. The cost is assessed against property within the assessable area and the hydrants are maintained solely by the Fire Department. Mr. Cramer mentioned hydrants installed especially for use in the sprinkling of streets. There are a number of such hydrants in Louisville, but for some reason city employees prefer to use the 6-inch fire hydrants rather than the 4-inch hydrants installed for sprinkling purposes. The maintenance of either class of hydrants is a source of no expense to the water company.

W. C. HAWLEY: I have been up against this problem for a long time and appreciate all that was said by the gentleman who read the paper. In our town, not only were they using the hydrants for all sorts of purposes, but were doing it under contract with the municipality providing that they should. After those contracts expired, we provided in the new contracts that the hydrants should not be used for any purpose except fire protection, unless with the written permission of the water company. We had some trouble educating the people up to that standard, but we have got to the point where

water for street sprinkling is taken from separate connections. If they want water for flushing a sewer or washing a pavement, we provide a man to operate the fire hydrant and make a nominal charge for doing so. We are perfectly willing to furnish them with the water in reasonable quantities, but we want to know it. We want to know that the hydrant has been operated so it can be inspected. The fact that in over twenty years we never have had a fire hydrant out of order when needed for service at a fire, is significant. Our worst trouble comes from the contractors who can go into the city of Pittsburgh and get a hydrant wrench. They are supposed to report when a hydrant is used, but if they do not report it to the city of Pittsburgh any more than they report to us, Pittsburgh is losing a lot of revenue. Our contract with the city provides that they shall not use the hydrants except for fire protection and we are getting along very satisfactorily. When we catch him at it we make it as expensive for him as possible, and they are learning.

HENRY P. BOHMANN: The city of Milwaukee permits the use of fire hydrants for other purposes than fire extinguishing, in the prosecution of construction work under city contract, such as street pavement, construction of sewers, the laying of water mains, the construction of curbing, sidewalks, street pavements, etc. All necessitate the use of water, and if the use of a hydrant is prohibited, I should like to know from what source they are going to get the water.

DOW R. GWINN: From the service pipes.

HENRY P. BOHMANN: The street railway company is responsible for the condition of the pavement between its tracks and for one foot outside. That means that all over the city they are making repairs. They naturally use the nearest hydrant. Then there is the telephone company and the gas company. I do not see how it is possible, in a large city, to prohibit the use of fire hydrants.

DOW R. GWINN: We have all those fellows trained now.

W. S. CRAMER: Does the electric company allow them to use electricity for driving their drills and welding apparatus, or does the gas company furnish them gas by direct connection to their

pipes? Why should we care any more about where they get their water than the gas or electric company care about where they get their gas or electricity?

HENRY P. BOHMANN: That all sounds very well, but in practice it does not work out; and I want to say right here that we have not a single revolving nut that shows the use of a Stillson wrench. Before a man is permitted to use a hydrant, he must take out a permit and make a deposit for the hydrant wrench, and nobody is permitted to use other than an authorized wrench given him by the department, and he must agree to be responsible for any damage done to the hydrant. We have what we call hydrant inspectors and each one is responsible for about 300 hydrants in his district. He oils and greases the hydrants and is responsible for hydrants in his district, and pays particular attention to the hydrants used by contractors. The Fire Department has never yet responded to a fire, winter or summer, and found a hydrant out of order.

A. S. HOLWAY: The street railway company is working through the streets, of our city, Oklahoma City, the boroughs are putting in sewers and pavements and doing work of that kind, but they do not take water from the fire hydrants, they get along without it. We have taken the position that we are under contract with the municipality to furnish fire protection, and if we permit the use of the hydrants for other things, we are assuming a responsibility which may be very serious.

DOW R. GWINN: They do get along without it.

ALEX MILNE: The situation is somewhat different as between the powers allotted to a private water company and the right to exercise those powers conferred on the plant operated by the municipality, even under the control of a separate company. You have your city engineer's department carrying on large projects requiring at times a large quantity of water, and if they do not get the use of the water from the nearest fire hydrant, there is going to be friction between the operating water board and the board of works and the one generally placed between two fires is the water superintendent. With us we have our city engineer's department entirely isolated from the water works department and still have a little friction.

Our regulations state that the hydrants shall be used for no other purpose than fire protection and no one shall have the right to operate them but the fire department and the water works employees. In the case of contractors we do occasionally give a permit. He must come to the office, make his application and get his permit, which gives him a hydrant wrench and a control valve. In some cases there is a reducer to $1\frac{1}{2}$ or $1\frac{1}{4}$ inches, or in the case of a small service to $\frac{3}{4}$ inch. Then he makes a deposit covering twice the cost of the goods he gets, which is refunded to him on their return and the payment of his bill. The only one I have trouble with is the city engineer; he has a sewer cleaning machine which takes a lot of water. Occasionally a sewer will get choked and we have touble with him. Only two weeks ago, just before I came away, the foreman of the street department reported to our office that there were two hydrants out of order from which he could get no water. I sent the foreman to one and I went to the other personally; in both cases the engineer's office man had tried to open the hydrant by turning to the right; ours all open by turning to the left; he broke the stems off and naturally could not get any water out of them. We had to take both hydrants out and repair them. Of course we billed the city. Fortunately that happened in the summer. In the twenty-three years I have been operating that plant we have never had the firemen go to a hydrant and not be able to get water. Last winter during the exceptionally severe weather, the only frozen hydrant was the one immediately adjoining the central fire station where the fireman had been fooling with the hydrant in cold weather.

Henry P. Bohmann: In the city of Milwaukee we compel the street car company to sprinkle between the tracks and they use the fire hydrant to draw this water. If we did not permit the use of the fire hydrants except for fires, I suppose the street car company would have to go outside the city to get water. Do you expect that would happen?

Stephen H. Taylor: For street car sprinklers we provided in New Bedford special flush hydrants alongside the car track at various points along the line. The charge for water is made in accordance with the number of tank loads returned by the street car company. When water carts were used special 2-inch hy-

drants were provided for their use, in order to eliminate the use of fire hydrants. Since the more general use of asphalt and cement surface streets, very little street watering is done now.

Rodney C. Wilson: I believe that fire hydrants, while primarily for fire protection, should also be used for other purposes. If other uses do not affect their condition and put them in bad order for fire uses. The majority of the fire hydrants are never used by the fire department, but when needed must be in first class shape.

In our city, Rockford, Ill., of 75,000 people there are many hydrants used for sewer flushing, street sprinkling, and by paving and sidewalk contractors, etc. They are the only available supply, and I believe that the convenience and time saved make the use, for these purposes, economical. The thing we try to guard against is the misuse and indiscriminate use by unauthorized people. The street and sewer departments employ men qualified to open and close hydrants and by simply reporting a hydrant when used we are able to keep a good check of their condition.

We have contractors order construction valves, which we install for them at a nominal charge. When a paving job is finished we are notified to take off the valve, when we also inspect the hydrant. The proper solution of the hydrant problem really resolves itself into only allowing authorized persons, who know how to open and close hydrants, to use them; also aiding contractors, by quick service in installing valves ordered, as well as having periodical hydrant inspection.

Dow R. Gwinn: The gas company want to use water for puddling their trenches; we send a man with a controlling valve and he stays on the job; they pay for the water and pay for the man's time. When he gets through, we know the hydrant is in good order ready for the fire department. If a contractor wants water where he has a street to pave, if the five-eighths taps brought up to the curb are not large enough for him, sometimes they connect up two, but if they have an extra large concrete mixer, we make a tap on the hydrant branch. We do that so that it will not be necessary to dig up the street to shut off at the corporation cock when the contractor is through. We set a meter and we charge him for doing the work and for the material, and then when he is through with the work we take out everything except the corporation cock and

give him credit for the salvage. It does not amount to very much, just the labor of connecting it up; so that takes care of the contractor on street paving. Now for the sidewalk work, they get the water from the service pipes along the different houses, we do not hear from them any more. We are practically all metered. They go in wherever they are working and get the water. Mr. Denman's father said a good many years ago they jay-hawked it. We have a contractor who is going to clean out sewers. He wants a large volume of water and must have it. We put a controlling valve on a fire hydrant and connect it to a three-inch Gem meter by a short piece of hose and furnish him the water. When he gets through, we shut off the hydrant, take off the controlling valve and it is all ready for the fire department, if they want to use it. I do not like to be in a position to make excuses to the chief of the fire department. When they want water, I want them to have it immediately, so they can get it without any trouble with the fire hydrant. So we get along very nicely with the fire department, just as if they were one of us. They are doing their part and we are trying to keep down the fire losses of the city.

Francis D. H. Lawlor: Might I ask if you can tell me of the methods of the Underwriters in rating a city? What deficiencies do they charge to a city if the fire hydrants are used by contractors and other departments?

Dow R. Gwinn: I do not know, because we do not allow them to use them.

Francis D. H. Lawlor: When the Underwriters' engineers inspect a city, they inquire into the use of the fire hydrants. If it makes a difference in the insurance rate paid by the property in the city, it is a pretty serious tax.

Dow R. Gwinn: And somebody has to pay it; the property owner is the man that pays it in fire insurance.

SUPERINTENDENTS' QUESTION BOX SERIES[1]

WHEN WATER IS FURNISHED AT FLAT RATES, WHAT IS DONE WHEN THE CONSUMER CLAIMS HE DOES NOT SPRINKLE?

HENRY P. BOHMANN: The conditions do not prevail in Milwaukee any longer. There was a time when those conditions did prevail and the consumer was charged for this connection unless the threaded hose bib was removed or the thread was spoiled so that he could not use a hose on it.

C. B. KNERR: In Bethlehem, on flat rates, we charge the consumer unless he removes the spigot altogether.

F. C. AMSBARY: At Champaign, Illinois, we treat such cases in exactly the manner described by the gentlemen from Milwaukee, but we have found that they often employ ingenious contrivances for fastening a hose to a hydrant that has had the thread removed. Where we find such cases we shut the water off and insist on a meter going in, and we always carry out that program.

DOW R. GWINN: We had a case where a man drove a small nipple inside of the hose spout on the hydrant and slipped the hose over the nipple so that he got the benefit of sprinkling. In another case they sent a little boy out with a rubber coat on and he would open up the hydrant, put his hand under the faucet and shoot the water over the street first in one direction and then another.

G. W. BRISBIN: I have been in the water business thirty-seven years. The only thing I would add to what has been said is that we have so many meters that we have hardly any cases such as you speak of, but we did make careful inspection when the time for sprinkling came about, or rather was pretty well along, so that when we saw green grass we said "That man is sprinkling, he must pay the rate."

[1]Presented before the Detroit Convention, May 21–25, 1923.

A member whose name was not given related the following experience: We had a little experience that way and we bought some seals and when the customer did not want to sprinkle, we would place the seal, at his request, on the hose connection, and the next quarter or the next six months if we found the seal intact we did not charge him for sprinkling, but if it was broken, he paid for that half year.

ISAAC S. WALKER: I have in mind the sad experience of a certain water works superintendent, now gone to his well earned rest in the great beyond. His rules stipulated that sprinkling would be permitted only between the hours of 6:00 and 8:00 a.m., and 6:00 and 8:00 p.m.; that sprinkling was limited *absolutely* to use of hand hose not larger than $\frac{3}{4}$ inch, that the hose should not be over 25 feet long, that no sprinkling should be done during a fire in the city, etc.

Our friend, through his well intentioned endeavors to uphold the Company's rules on this point, had aroused the ire of certain citizens. One morning, on his travels around the town, he discovered a lady sprinkling out of hours. She was furthermore sprinkling the street, instead of her lawn, which was another infracton of the "rules," which I forgot to mention above. He had the temerity to protest her action, whereupon she proceeded to drench our friend with his own water. It is not recorded that he ever again challenged her rights to sprinkle.

In spite of any rules which could be formulated on this question, if a consumer has water on the premises, and wants to sprinkle, he will sprinkle. And incidentally, he will brag to his neighbors, how he puts one over on the water company. Any attempt to enforce regulations of this character is a mistake. It simply makes an enemy of a consumer who otherwise would be a friend, and good friends are needed in the public utility business.

The answer to the question is—put a meter on the consumer's line, and let him sprinkle to his heart's content—the more the better.

J. M. DIVEN: The first part of Mr. Walker's advice is sound, put on meters, get pay for water used for sprinkling lawns and streets and do not make too many restrictions as to hours, kind of hose, etc. matters which lead to friction if not to an occasional ducking. But, considering the peak of load, are not restrictions, reasonable restrictions as to hours for sprinkling wise and reasonable? In a manufacturing city, in fact in most cities, two-thirds of the day's consumption

is used in the eight working hours, two-thirds of the consumption in one third of the time. This brings a heavy load on the pumps, on the filter plant and on the distribution system. Is it not reasonable to ask citizens not to add to the load at these hours, or even to demand and require that they do not? Cutting out the hours from 8:00 a.m. to 5:00 p.m. leaves them sixteen hours to sprinkle, which ought to satisfy all reasonable demands.

WHERE THERE ARE SEVERAL FAMILIES USING WATER THROUGH ONE METER, HOW MAY COLLECTIONS BE DIVIDED?

G. W. Brisbin: We put on what we call a master meter, and any number of subsidiary meters that the party desires, but we render the bill to the owner of the property. We will not render any bill to the tenants. We give the tenant or the secondary tenant a bill that shows him how much his proportion of the total cost is and that seems to answer the purpose very well. We tried several different ways: letting people have two meters and rendering the bill for the whole to the owner, but that did not work very well, so we said that no meters would be installed unless there was a master meter and then they could put on as many subsidiary meters as they liked.

Henry P. Bohman: In Milwaukee we recognize only one meter, that is, the master meter; if the consumer wishes to put on a sub-meter it must be done privately by him, because we do not recognize sub-meters, for you cannot shut off the water supply to premises controlled by a sub-meter without shutting off the main consumer, and I have found that sometimes the sub-meters register more than the master meter.

Dow R. Gwinn: It is a very good thing to have a landlord pay, but in some cases the landlords object seriously and want you to put in three, four or half a dozen meters and let each tenant pay for their own supply. That makes more or less trouble. We tried for a while to make them start in from the sidewalk, have a separate curb-cock on each, but that seemed to be rather an imposition on the property owner and cost him too much money, so we try as far as we can to make the landlord assume the payment for the water used for the whole house. Of course the landlords complain; they say "this fellow has a grudge against me, I want to get him out and he will not move out and so he lets the water run and makes me pay a great big bill for it." I heard of one case where a landlord told each tenant he was paying about so much a year for water, and said, "Now I have

allowed $2 a month for your water bill; if my water bill runs up very much more than my estimate, you will have to pay more rent," and he said it was working out very nicely because each one then had an incentive to look after the water. We had some cards printed in red ink, which we distribute among our customers that they can paste up where the water is being used, a notice to the tenant that if there is a leak in any of the water closets or faucets, to notify someone and then fill in the name of the person to whom they want to refer.

ARE DEPOSITS DEMANDED WHERE WATER IS FURNISHED BY METER? IF SO, HOW MUCH AND DOES THE COMPANY OR DEPARTMENT PAY INTEREST?

Dow R. Gwinn: In our case we ask for a deposit, $3, in the case of dwelling houses, unless the owner lives in the property or will be responsible for it. We allow them 4 per cent interest on deposits if they remain six months or longer. It has worked out very well.

F. C. Amsbary: At Champaign, Illinois, we followed the same method as Mr. Gwinn, has just told us of, until quite recently, when the Illinois Commerce Commission issued a bulletin laying down rules that we must follow in the case of deposits or guarantees. But after studying those rules and regulations we found they were so complicated that we decided to abandon the charging or the practice of requiring a deposit, taking our chances on losses. We think it would cost more to carry out these rules in bookkeeping and investigations than our losses would be if we required no deposit. Fortunately the Commission states that there is no objection to a water company extending credit to any consumer.

Ray Crozier: At Peoria we make the property owner entirely responsible. In signing the application he agrees to be responsible for his water bill. If he wishes the bill sent to the tenant we do that for him, but in case the tenant does not pay, we hold him responsible. At the end of thirty days we shut off the water unless the bill is paid. In that way we have very few losses.

Henry P. Bohmann: In Milwaukee water rates are assessed directly against the property served so that we do not have the troubles that private companies have. Water rates are a lien on the premises and while our revenue is about $2,000,000 a year, we have yet to charge off the first dollar to profit and loss.

Dow R. Gwinn: You run no risk if you take a man's property.

JAMES E. GIBSON: In Charleston, S. C., we use the same method as Mr. Gwinn, except that we allow the customer 6 per cent interest on his deposit. We do not keep a separate account of this money, but deposit it in our regular checking account. We pay no interest for a shorter period than three months. We accept no guarantees from the owner unless he signs the regular prescribed form of contract and we insist upon sending the bill to him unless he makes a deposit, in which case we will send the bill to the tenant. We get stuck a good many times. The amount of the bill, for instance, may run to $25 and the consumer has only a $5 deposit. The customer promptly moves or disappears and we lose track of him. Under these circumstances we confiscate the $5 deposit, and put the customer's name and amount on our black list. I might add that our black list is now beginning to pay dividends. I think last year we collected more on our black list than we charged off for bad debts. In South Carolina the water bill is not a lien on the property, either municipal or private. Some of the municipalities by ordinances make the bill a lien on the property, but this is simply bluffing it through; other municipalities refuse to make contracts except with the property holder. We have not followed either of these courses in Charleston, as the custom of the former company was to make contracts with anyone and the only change we have made is to insist upon a deposit where the consumer is not the owner of the property taking the water.

DOW R. GWINN: We ask a higher deposit from a livery stable or a soft drink parlor, $5 or $10, according to how the bills have been running. We call it an advance payment, and where the customer makes an advance payment of $3, $8 or $10 we charge him each month for the water used and send him a statement showing the amount still to his credit. He gets no interest on that, but it saves him the trouble of making out a check every month for the bill. We have about 100 of our customers who do that. There is one water works down in our neighborhood that has an arrangement whereby they deposit the bill in the customer's bank and they give instructions to the banker to charge the bill to their account the same as a check. That also works out very nicely.

RAY CROZIER: Do you think that would work out very well with a meter? Telephone companies do that on a flat rate basis, but if a man had an excess or a leak or something like that, it would work a hardship. He would have to check up his bank account every month.

DOW R. GWINN: It might wipe it out. But water bills are so small they seem insignificant.

H. T. WATTS: At our plant, Vincennes, Ind., we are charging deposits in accordance with the rule of the commission. I think it went into effect sometime in 1917. I do not recall its exact stipulations, but it prescribes that we cannot set up a deposit charge of more than 50 per cent in excess of an average monthly bill, so the charges run something like $1.50 on a $\frac{5}{8}$ meter and up to $6 and $7 on a 4-inch meter. One of the provisions is that we shall only charge these deposits in certain cases. That is, it is not the intention to charge them in all cases, but only when there is a doubt as to our ability to collect. It also says that deposits shall be charged in such a manner as not to discriminate against consumers. Those two requirements conflict; if you charge one consumer a deposit and do not charge another, you immediately have the one that you did charge on your trail. So you have discrimination right there, if you attempt to follow out this ruling of the Indiana Commission. That is the way it worked out there. It has been in effect about six years and I think we only have about $400 altogether in our deposit fund. At Chester, we have about $34,000 or $35,000 of deposit money on which interest is paid at 4 per cent. It is not compounded but simple interest; the compounding of such small amounts we have never gone into, but we exact a deposit from every consumer in Chester, and there is no discrimination between tenants and property owners.

DOW R. GWINN: The water works company must be the judge of whether a man should make a deposit or not. I would not ask a banker to make a deposit. I have a form of letter I use where the clerks take a deposit from a man that I know is perfectly good and when I come across a case of that kind, we send him one of these letters saying that the clerk was perfectly right in taking the deposit because we required them to take deposits, "but you are not one of those kind of people; if you bring this letter to the office, the money will be refunded;" and a man appreciates that.

STEPHEN H. TAYLOR: At New Bedford, Mass., we require an advance payment of $5 a year as a minimum charge, also $1.50 to $3.25 a year meter rental, according to size of meter; that allows the

use of water to the value of $5. We render bills quarterly for the excess, and if these bills are not paid within a reasonable time, we shut off the water. We have no other advance payment. We recognize only the owner of the property in our collections. Sometimes as a matter of convenience we send the bill to the tenant, but if he does not pay, the owner is still held responsible. In fact, he signs an agreement to be responsible before the water service is put into his property. If the owner wants to subdivide it he puts in meters inside at his own expense, but bills are rendered to the owner for the amount indicated by the main meter.

Dow R. Gwinn: They had a case in Massachusetts where they had a minimum charge of $10 and at the beginning of the year every customer had to make a payment of $10 to begin with. Then they did not get any more bills from the water department until the $10 had been used up. I thought that was about the nicest way I ever heard of, but, with privately owned water works, we would have a pretty hard time trying to get men to come to our office and lay $10 down on the counter. It is hard enough to get them to lay down $1.

Stephen H. Taylor: That is what we do at New Bedford, except that our charge is $5.

F. T. Lamey: Our consumer in Chester, Pa., deposits $3 for a $\frac{5}{8}$ meter and up to $12.50 for larger meters. We make everybody pay. Every tenant, who comes in and presents a letter from his landlord authorizing us to sign him for his service, must make his deposit. We undertook to pick out a few isolated ones that we thought were all right and we got into hot water because Tom Jones would come in and we'd think he was all right, and maybe the next week John Smith would come in and we would make him make a deposit. One would tell the other and we found it was a pretty ticklish job having a man come to the counter and show his deposit slip and have to tell him that we did not consider him a good payer of bills and he had to make a deposit. So we turned around and required everybody, even the highest banker in town, to make a deposit. With that class of people we find we get along better with the explanation that it is a matter of business. We get along far better than if we tell a man we do not think he is any good, for it makes him angry at once. We do not have any trouble. We have about $35,000 collected on deposits and a lot of money in that fund

that I do not suppose we will ever have to return, money of people who moved away and we do not know where they went. Our population was made up of transient tenants during war times and they moved away. Many of them were foreigners and others skipped out after a bad leak and we had to confiscate the $3 deposit to offset a $25 leak or thereabouts. We get along pretty well now and work along every month trying to eliminate the old ones wherever we find them. Then we notify them to come and get their deposit. That is the way we get over it, by making everybody pay.

P. J. HURTGEN: In Kenosha, Wis., we make the owner of the property sign up for the meter and then we hold the property for the amount of the water bill, and if it is not paid within a certain length of time the water is shut off. As far as repairs and such as that are concerned, if for any reason we do not get it, it goes on to the tax bill. It seems to me that this thing of making one man make a deposit and not another is not exactly right. I think they should all be treated alike and that will be a more popular plan than to require it of one and not of another.

CHARLES B. YOBST: Fort Wayne does not require any deposits. We have a contract card and any freeholder who will sign the contract has the privilege of using water and we do not have a bit of trouble.

JAMES E. GIBSON: I would like to ask Mr. Walker and the gentleman from Chester what they do when a man does not pay his bill. We have this trouble in that we require a customer to put up a deposit of not less than $5 when he is not the owner of the property. His bill each quarter amounts to a minimum of $3.00. The bill is mailed to him, and, if at the end of ten days it is not paid, we send him a final delinquent notice and if we do not get a response from this notice within five days we shut the water off. Immediately he comes forward with the statement, "You have got $5 of my money; why do you not take it out of that rather than shut me off and charge me a fee for restoration of service?" I should like to know how they handle this condition at Chester. We answer this query with the statement that we are paying him interest on the $5 deposit and consider we have no right to touch that money on deposit, until he ultimately refuses to pay the bill, but you can readily see that this answer does not always satisfy the consumer.

F. T. Lamey: At Chester, Pa., we follow along the same lines you do, only we charge him $2 to get the water back in place of $1. We often have them come in and claim that we have no right to turn off the water unless their bill amounted to more than the $3 deposit which it invariably does before we shut them off. The only ones we do not like to shut off are the 58 cent minimum bills. We have two minima, 58 cents and $1.15. A man has to run several months at 58 cents before he eats up his $3 deposit, then we have his $3 and shut him off for a couple of months at 58 cents and then charge him $2 extra and we hate to see that done. We have a case in Chester of a business man who has never paid a bill on time, probably in the last five years. He has his place of business in the house where he lives and he has three tenant houses. He takes care of all the bills about every other month; we shut the whole outfit off and he pays $2 apiece and he never pays until we shut them off; then he comes in and pays and has a nice pleasant talk. He says, "Oh yes. I know that's your rule. I have got no kick coming, it is my fault, but I forgot it," but I honestly feel more ashamed about doing that every second month than some of these others.

Isaac S. Walker: Supplementing Mr. Lamey's remarks, I might say that we have no penalties in Chester. We have no way to encourage them to pay their bills promptly and if they do not pay them the only thing to do is to shut them off under the present rule, which is a very sad state of affairs.

Chester R. McFarland: Our Company, The Tampa Water Works Company, requires a deposit of $5. This deposit is to cover any unpaid bills at the time of vacating the premises. We do not pay interest on these deposits, but we believe it should be done. We render all meter bills on the first of the month and the flat rate bills are payable at the office between the first and tenth of each quarter, that is, January, April, July and October.

All bills paid on or before the tenth of the month in which they are due are subject to a discount of 10 per cent; after that date, payable without discount. The bills are then given to a collector who presents them and, if not paid, a notice is left stating the bill will not again be presented and if not paid at the office in a reasonable time, usually about five days (which time is stated in the notice), the water will be cut off without further notice. If it is not paid, the bill is then given

to the turn off employee and he again presents the bill and if not paid, the water is cut off. Before it is again turned on, the consumer must pay all bills due and a fee of 50 cents for turning on the water.

The Company finds this method quite effective and the losses for bad accounts are small at the end of the year.

The Company finds the method of allowing discount quite satisfactory, as about 90 per cent of the consumers take advantage of the discount and pay their bills on or before the tenth of the month. This has good results in two ways, the customer is pleased to get the discount and the Company is saved much labor and expense.

ROBERT E. DAUGHERTY: In West Palm Beach we have two municipalities to deal with, Palm Beach and West Palm Beach. We require no deposit for the meter, but in Palm Beach we do require an annual payment of $30 which allows a stipulated quantity of water. The bills in Palm Beach are rendered once a year, because we are unable to reach our consumers in Palm Beach except during the three months of the season, January, February and March. Those bills are rendered on the first of January, and all water used over and above the allowance is included on the bill next January. Those bills are payable by the 15th of the month. The bills in Palm Beach run very large; to give you an idea, we have fifteen or twenty homes in Palm Beach that have 4-inch meters and one man the other day gave me an order for a 6-inch meter for his small residence. In West Palm Beach our bills are rendered for $3.60 a quarter, payable in advance, allowing a certain quantity of water and the same procedure followed as just outlined for Palm Beach. We have perhaps 75 per cent of our consumers in West Palm Beach that have excess water which is billed on the bill with the $3.60 for the next three months. The only penalty we have is that, if the bill is not paid within fifteen days after it is rendered, the water is turned off and $1 is charged to turn it on. We find that is a pretty good rule to live up to, because we charge off very few bad debts and the system works out very well with us. Of course, we have conditions that would not apply in many other cases.

W. B. LIVEZEY: In Newport News we do not charge a deposit. We have quarterly bills for domestic service, monthly bills for commercial service. We have minimum charges payable in advance, for a stipulated amount of water. We do not charge anything for

turning on the supplies. Our curb box key is our best collector; we have very few delinquencies and not many losses. We have a fairly large floating population, and for that reason we must collect in advance.

J. F. Willett: In Billings, Montana, we have a minimum charge of $5 for all tenants. We require no deposit from a property owner. We pay 6 per cent interest on deposits. We are 100 per cent metered and there is no charge for turning water off and on except for collections, which charge is $1.

F. A. Bunks: At St. Joseph, Michigan, our collection system differs somewhat from any I have heard given here today. We hold all property owners responsible for all water used on their premises. The property owner must make application for water to be turned on. For this reason we demand no deposits when turning on the water supply. All bills are rendered quarterly, except where large quantities of water are used and these we bill monthly.

When we find a customer lagging with his payments we send him a shutoff notice; but it is seldom that it becomes necessary to shut off the water.

At the end of the year we find some customers, to whom we have granted time extensions in payment of bills, have not paid as per this agreement and we begin a collection campaign. We notify the public through the local papers that the water will be shut off at a given time if all back bills are not paid in full at that time. A few days after this given date we again use the local papers notifying the public that we are using the water key and if they do not want the inconvenience of being without a water supply to come in at once and pay up. It does not become necessary to use the key on more than one half of one per cent of our customers.

Our greatest loss is from small manufacturing concerns just starting that will do business for a few months and then go to the wall.

Alex Lindsay: I like the attitude of the gentleman who has just spoken. It is apt to arouse resentment in the consumer and also reflects on the ability of the department as a collector to resort to turning off water services. Most consumers will pay their water bills if given reasonable opportunity. Those who are financially unable to pay should be reported to some charitable society for aid. In

Spokane, Wash., we turn such cases over to the city's Social Service Bureau, which institutes an investigation and in proper cases pays the water bill as well as other bills involved in the community care of the family.

DOW R. GWINN: Still you have to shut off sometimes.

ALEX LINDSAY: Our water bills are sent out on the first of the month and on the 20th they become delinquent. Instead of cutting off those who have failed to pay on or after the 20th, notices of delinquency are sent to the properties involved. This brings payment of a large proportion of the back bills. Ten days later a second notice is sent to the places still remaining delinquent. Not until after this second notice is the list of remaining delinquents turned over to the chief inspector for turning off services. We have 28,000 services in Spokane. During the last five years we have shut off for delinquency an average of only about 30 services per month, and the majority of these had become vacant after the meter reading was taken. If a water bill is not paid within a year, and we have very few of these, a lien is filed against the property served. As a result of our practice in this matter, we have no uncollectable bills, and very few cutoffs which have inconvenienced householders.

DOW R. GWINN: That is different; there is a whole lot of difference in running a city water works, where you have a lien on the property, and a water works where the company has to hustle out and get the money in order to pay the taxes.

STEPHEN H. TAYLOR: At New Bedford all bills are due quarterly, beginning July 1. Under the old regulations, bills remaining unpaid on the 15th of the month may result in shut off for nonpayment. The old method was to send a man as soon after the fifteen days as convenient either to collect the bill or to shut off the water. The result was that many people acquired the habit of waiting for us to come and collect the bill. Under the new rule, fifteen days after a bill becomes due, we issue a written demand on which 10 per cent of the amount of the bill is added. If the bill remains unpaid thirty days, we shut off the water without further notice and make a charge of $2 additional before it can be turned on again.

WILLIAM R. YOUNG: In Minneapolis we find that by waiting for notices to be sent to the delinquents, as the last speaker said, people wait for those notices. With us, we send a regular notice on the first of the month and on the 20th of the month that bill becomes delinquent, although there are no penalites until after the water is turned off. In a municipal plant such as ours, however, we wait until we send a second notice giving the occupants a chance to come in and pay their bill, and then we make our delinquent notices out and send them to our street service department which sends its men around serving another written notice, giving them twenty-four hours to pay the bill. If they do not pay the bill at that time, we charge them a $3 penalty, because we found that a great many people waited for that third notice and there was no necessity for their waiting for the third notice. By turning them off, we have no trouble getting the money. A speaker said they lose money on the manufacturers, but we do not lose any money on any of them because the water is turned off and the piece of property that may have that water connection does not have any service for water until all back charges are paid, together with the penalties for turning off or repairs if necessary to the stopcocks. It has been suggested by some that we reduce the $3 charge to a $1 charge, but every fall in the northern country there are a great many vacant houses and we have a charge of $1 for turning off water for temporary vacancy and the real estate men who may have 30 or 40 or 50 houses would let the delinquent bills go if we had the $1 charge until such time as they rented the house again, but, with the $3 penalty, they will immediately come in and pay the bill and we do not have to carry the unpaid bill until such a time as they want to use the water again.

CHARLES EVANS: In Lima, Ohio, we try to be lenient with the public and give them a whole lot of notices and half of them swear they did not get them. We have added a 10 per cent penalty to the bill which is payable quarterly and we turn their water off if they do not pay it by the 20th of the month. The bill is due on the 1st and payable on the 10th and after the 10th the penalty goes on. Around about the 20th if they are not paid, we shut the water off. We add the penalty when we turn it on. If they do not pay their water bills and it runs over three months, there is another 10 per cent penalty added. We have found that the best way to notify them is after turning the water off and they will not come back and tell you that

they never got a notice of that kind. Now Lima is a growing town and there is a shortage of houses. Whenever a house becomes delinquent, it is not delinquent very long, because somebody wants to move into that house as soon as the tenant moves out, so we are not bothered very much. But we have become stringent on this penalty. We found that the easier you are with the public, the more they will take advantage of you, so we turn the water off and then notify them that it is off and tell them why, and they come in and pay.

ALEX. MILNE: This is getting quite interesting and sounds like home. I have not heard any of the speakers remark what percentage of delinquents they have on their roll. Our methods in St. Catharine's, Ontario, are very similar to those of Mr. Young at Minneapolis. We give a discount of 10 per cent if the bills are paid on or before the 20th of the first month of the quarter. If they are not paid on the 20th, the discount lapses and the bill becomes delinquent; if not paid on the last day of the quarter, 5 per cent is added and at the expiration of ten days a special peremptory notice is sent all delinquents giving them until the 20th when the water may be shut off without further notice. With a little over 6000 flat rate consumers, we turned off one consumer last week. The water tax becomes automatically a lien on the property, but strange to relate, I find that the majority of my delinquents are nearly always the same bunch from one quarter to another; 90 per cent are perfectly able to pay the rates. Our best payers today are the despised Polacks and Italians living in the shack districts in the suburbs; they pay their bills promptly and take all discounts.

JAMES E. GIBSON: I wish I could say that we had only turned off one customer in the last six or twelve months. We have to turn off on the average of about sixty each month for nonpayment of account. We have the continuous system of reading meters; that is, we read approximately 200 meters each day and send out bills for a like number. Therefore, the bills are paid at about this rate, two hundred per day.

When the service is discontinued for nonpayment of bill we refuse to restore the service until a payment of a fee of one dollar for restoration of service is made. The only exception to this rule is in case the party has moved and a new party has taken the premises, in which case we compel the new occupant to enter into a new contract and assume the water bill from the last reading of the meter.

Our experience is about the same as at St. Catharine's in that those who can afford to pay are slow to pay, and the best cash customer we have in Charleston to-day is the negro. He does not expect accommodations, does not ask for them, and, therefore, pays as he goes.

Dow R. Gwinn: We have digressed a little bit from the original subject, but this is your meeting and if this is what you want to talk about, that is what we are going to talk about, so I will tell you what we are doing in Terre Haute. We started out this morning reading our meters for the month. We collect monthly and on the last day of the month the bills are due for the current month and we send those bills out to the premises giving everyone an opportunity to pay. We get in some extra help, a number of ladies who are doing their own work at home; they come down and make $3.50 by working from 8:00 a.m. to 5:00 p.m. We do that once a month; it takes about two days to deliver our bills. They are divided up into thirty-five routes. Forty per cent of the bills are paid when they are delivered. We do not employ collectors, but we employ bill deliverers who deliver the bills to the premises and give the consumers an opportunity to pay if they want to and save the trouble of coming down to the office. If the bills are not paid we do not make a second trip unless there is something unusual like sickness in the family and they telephone they would like to have us come out. They have ten days in which to pay. On the eleventh of the month there is 10 per cent added to every bill, and we collect it. On the evening of the 11th we mail delinquent notices to those who have not paid.

Mr. Milne raised the question about how many delinquents we had. A delinquent is one who had used water and had about twenty days more leeway. All but 7 per cent of the bills are paid by the 10th of the month; then we send out notices on the 11th and get a grand rush the next day; they are the ones who forget or who were out of the city, but the balance are the ones who are on the delinquent list every month. About the 14th of the month we send out notices saying, "We will not guarantee you a water supply unless the bill is paid by the 16th." That brings in a lot more of them. Then on the morning of the 17th we start our men out. They are kind hearted men and they do not like to shut off the water. After one man came back from making the rounds he was asked, "How many did you shut off?" and he replied, "I did not shut off any." "But you had orders to shut them off." "Yes, but they said they were coming

down right away. One lady was washing. One told me they had sickness in the family and I did not like to shut the water off." But that last bunch is pretty hard to get in, so that by the end of the month perhaps out of 9500 bills we will have about 100 to carry over to the next month. That is a small proportion, but we do not reduce it to that number except by ding-donging and keeping after them all the time. The big problem in the water works business is, "How are you going to get the money in?" We can filter water with a turbidity of 3000 and with bacteria of 25,000 and get a satisfactory water, but it is easy work compared to getting money from a few of those people who do not want to pay. Yes, Mr Hurtgen, we add the 10 per cent penalty to their next bill.

P. J. HURTGEN: I am interested in that for, commencing the first of June, we have adopted a new rule by which we are going to follow that same plan. We are going to add a 10 per cent penalty on bills that are unpaid. Our bills are due from the 1st to the 10th, and on bills not paid between those dates, 10 per cent penalty will be added. Now I have not decided on the delinquent notice, but I expect that I will send out a delinquent notice after the 10th notifying them that the penalty will be added to the following bill. We only collect twice a year. We have our system divided up into three districts and are collecting every other month in one of those districts. This rule was followed for in each district we have about 3000 consumers, and between the 1st and 10th of April, in one district out of 2800 there were probably 250 delinquents. We would send out a delinquent notice and then a final notice that we would shut the water off, and we would still have out of 3000 probably something like 200 people to shut off. So we have adopted this new rule that 10 per cent penalty will be added after the 10th of the month and the water will be shut off without further notice on the 21st. But in the meantime we will send out the delinquent notices and we believe that in that way we are going to get most of them to pay their bills. These new bills will be printed in red.

DOW R. GWINN: We did that, too, but those chronic delinquents are hard boiled and do not pay much attention to red ink.

CHESTER R. MCFARLAND: The question is whether it is just to add a penalty to an unpaid bill. We are nothing but merchants doing

business; if you are merchandising, you will give a man a discount for paying his bills promptly, but if he does not pay, you do not penalize him 10 or 15 per cent because he does not pay and I think that is a source of antagonism. I have tried both ways and I find it is better to give them a discount for paying their bills, but not to penalize them because they do not pay but induce them to pay, if they do not pay within a reasonable time, by discontinuing service. The case is the same as that of a merchant who discontinues furnishing goods if they are not paid for. A grocer will not keep on furnishing goods if you do not pay your bills. If you cannot get your money in to pay the expenses of running a plant, you will necessarily have to stop, so that forces their attention that it is just as necessary to pay their water bill as their butcher bill. I think you will get better coöperation from every customer in that way than by penalizing them. That is a suggestion I will offer. I do not consider it proper and just to penalize a customer by adding a percentage to his bill.

J. F. Willett: The Montana Public Service Commission does not allow penalizing; they say we cannot penalize the customer, but we allow 10 per cent discount up to the 10th; after the 10th they must pay the full face of the bill. After the 12th we send out delinquent notices; then if the bill is not paid, we send the shut-off notices by registered mail, because we find so many people who say they never received that notice. I have had some of them say they did not receive it where we had their signed receipt in the office, but there are very few of that kind. We send a registered notice to all shut-offs.

ARE CONSUMERS ALLOWED TO DO PLUMBING FOR THEMSELVES? IF SO, HOW IS THE DEPARTMENT OR COMPANY TO KEEP RECORDS WHERE SERVICE IS ON A FLAT RATE BASIS?

Stephen H. Taylor: At New Bedford we install the service with our own forces to the street line, and, if the customer desires, which he almost always does, we lay it inside the building. The plumber puts on a meter there and goes ahead. We are practically 100 per cent metered.

G. W. Brisbin: We furnish the service from the water main to the curb or service box, and from that point in it is taken by a plumber. The plumbing of Battle Creek is done perhaps as cheaply as any city with which I am acquainted, and more so than most of them, and we have very little difficulty. Once in a while a man does some secondary plumbing after the first installation, and does it himself, and if it is not good, we make him take it out and install it correctly or have a plumber install it correctly. We do not have any of the trouble that this question seems to call for. Perhaps that is partly because we have the installation of the service from the main to the curb box; we do not allow anybody, willingly, and very few do it anyway, to put in plumbing of any kind and I do not think it ought to be done. We had a great many frozen fixtures and a great many fixtures that were installed improperly in other directions, simply because property owners and their help and friends tried to do plumbing, so we stopped the whole business of persons doing plumbing in any way whatever. I do not think that the average city need be troubled with that sort of trouble at all, if they will install the service themselves and have a licensed plumber to do all the work, at any rate all that amounts to anything.

Henry P. Bohmann: As I interpret the question, it means how does the water company make charges for fixtures that are installed without the knowledge of the water company. I think this is a mighty big problem. I remember reading the report of a large

water works in which it prided itself that it had collected $15,000 for connections in one year that the water company did not know anything about. I think no one should do any plumbing except a licensed plumber under a permit issued by the city.

Stephen H. Taylor: At New Bedford when we were operating under the fixture rate, we sent an inspector to every house once a year to thoroughly inspect all fixtures and in that way we kept track of the fixtures in the house and checked up the leakage. We had at that time a maximum rate, and after the fixture rate amounted to $13.50 the owners could put in all the fixtures they wanted without further charge. Up to that point, however, the fixtures were kept track of by annual inspection.

Theodore R. Kendall: In Nyack and South Nyack, N. Y., there is only one annual inspection to determine the number of fixtures in the house and this inspection takes the form of merely questioning the housekeeper at the door. I believe that if the same type of inspection is customary in large communities, a good deal of money would be lost to a water department by having only one inspection of flat rate customers a year, and that taking the word of the consumer. There may be 100 or 1000 or 5000 fixtures put in between the annual inspections which means a material loss in revenue. Does anyone here know of any places that are inspected more than once a year as Mr. Taylor speaks of in New Bedford?

Alex Livezey: My company has some fixture rate connections. No one is supposed to do any plumbing in Newport News except a licensed plumber. We do not, therefore, allow consumers to do any plumbing. We have frequent inspections, probably twice yearly, on the few flat rates that we have. I think the solution, however, to this problem is 100 per cent meters.

Chester R. McFarland: In Tampa we make one annual inspection in the spring of the year, about the time they begin to put on the sprinklers. We have a rule that, if we find extra fixtures installed which we do not have on the books and which have not been applied for, we charge them for the quarter we find them on and the quarter before that. If they install a fixture and have not reported it to the office and we find it in the quarter between April and July, they have

to pay for the current quarter and the back quarter. We also keep our inspectors going all the time in addition to this annual inspection; they report every house and every fixture, but if we suspect there is work being done on the houses of which we do not have records, we send a *suspicion* inspector to look it over. We have just made an inspection and have collected enough money from this annual inspection to more than pay all our inspectors for the first six months of the year. They will put on additional fixtures without reporting them and you cannot stop them. When I first investigated that matter, I found there was no law that would permit us to license plumbers unless there was an official ordinance of the City Council. The City Council would not grant that, so there was nothing for us to do but follow it up by annual inspections. We have a great many people in our country who are natural born plumbers and they work for themselves and their neighbors and friends, and we have to watch them all the time. I think there is only one remedy and that is constant inspection of the premises.

C. B. Knerr: The way we do it in the city of Bethlehem is as follows: We have six inspectors continually going around; once every two years we make a physical inspection of every house, and that means something when you have 13,000 and some odd services and about 75,000 spigots. The tenant has no right to put in spigots, but they put them in. The plumbers do so too. We have licensed plumbers, and when we find out who has put fixtures in, we have a fine of $25 and costs, and in that way we keep them in check. We have fined some tenants already $25. We have to make an example of some one. The Public Service Commission has nothing to say to us in the cities; we are our own bosses. The only solution to this is 100 per cent metered services.

Muscoe Burnett: The gentleman from Florida has just stated that his company was not permitted to license plumbers and require them to do all work under the Water Company's rules and regulations, unless the Common Council of his city passed an ordinance to that effect. I am interested in learning if any member present is familiar with any court decisions that have or have not held that a privately owned water plant has the right to license a plumber, and also to require the plumber to furnish a bond, other than a decision made by the Kentucky Court of Appeals in a suit in which the Water

Company of Paducah was a defendant. In Paducah the City Council passed an ordinance, carrying out a mandatory clause in the water company's franchise, giving the water company the authority to license all plumbers, and also an ordinance making it a crime for any plumber to extend or repair any pipe or fixtures connected with its mains. The Kentucky Court of Appeals held that a city owning its water plant had a right to enforce such ordinances, but that it could not delegate such power to a privately owned plant.

Our company has had little trouble with the established plumbing firms, all as a rule reporting all work done by them. We are having trouble, however, with a class of cheap mechanics attempting to do all kinds of plumbing and who are not getting permits from the water company for any of it. We are considering the advisability of again taking the problem into the courts. I should be glad to learn if any one here, representing a private water company that is requiring a bond with a license, has had its rights along these lines tested in the courts.

Dow R. Gwinn: Replying to the question whether any private water company was given permission to issue license, we never asked the permission for our company, we took it for granted that we had that power; we are running the water works business in the interest of the citizens, and in order to take care of them, there must be certain rules given for the plumbing. The city has a plumbing inspector who looks after the sanitary part, and the water company has certain rules governing the putting in of fixtures, specifying what kind of fixtures may be put in. Of course the question has been raised sometimes, on several occasions I guess, "I'm paying for this, I'll put in what I please," with emphasis. "Oh, yes, that is true, you are paying for it, but we are furnishing the water; we are on the other side of the contract, it takes two; if we have to supply you with water and take care of you, we must have rules governing how we are going to supply it and through what connections. You are allowed to use water, but we cannot give you all the water that we pump; we give you your proportion, but we must specify the size of the service pipe." A man will come in and say, "I want a 6-inch pipe." "We cannot give it to you. What do you want to do with it?" "I want it for fire protection." "We do not allow anything larger than 4 inches." "Well, I want 6." "You cannot have it." I have to explain to him that we are operating a direct pressure plant and we must fur-

nish, first of all, the public fire protection which is paramount. Another man will come in and raise the question about the kind of water closets he will put in. Our rules do not provide for flushometer closets; they have some in there, but they put them in contrary to our rules. Of course, they are supplied through a meter, but we will not supply a large pipe for a flushometer unless the other requirements are such that it makes a large pipe necessary.

The question as to our authority to license plumbers was raised some years ago and the plumbers employed a lawyer, but they did not have enough confidence in their case to take it into court. Our attorneys held that we were right and the others were afraid to go in and try it out, so we required licenses. Before we issue the license, we require a bond of $1000 that they will do the work in accordance with the rules of the water works company. Of course that is not all there is to it, that is just the beginning; the troubles come afterwards; but it saves us a lot of trouble with the plumbers when we have got a $1000 bond on file. We never have had occasion so far to collect on that $1000 bond, but it has a good moral effect on the plumber. He is a little more careful than he would otherwise be. Coming to the question about putting in the pipe, if the plumber says, "I can put in anything I please," we say, "You cannot put in black pipe, if you do we will not turn the water on for you; it must be galvanized or lead pipe," because we do not want our customers served with rusty water.

CHESTER R. MCFARLAND: Suppose the plumber does not comply with the rules, puts in fixtures and does not report them; can you enforce your remedy on those bonds?

DOW R. GWINN: I think we could, if necessary.

CHESTER R. MCFARLAND: I doubt it.

G. W. BRISBIN: A franchise for a water works is a contract between the city and the company, and I think it depends entirely on what that franchise says, how far you can go with plumbing regulations or anything of that kind.

MUSCOE BURNETT: In Kentucky the courts have held differently.

G. W. Brisbin: That it depends on the franchise?

Muscoe Burnett: No, sir; the courts have held that the city has no right to delegate that power to a private company.

Charles B. Yobst: At Fort Wayne, Indiana, we have a plumbing ordinance passed by the Council and we hold the plumber with that.

Dow R. Gwinn: Your plumber's ordinance is different from ours.

Charles B. Yobst: The Council issues all ordinances for plumbing, sewerage and everything else.

Dow R. Gwinn: We have no franchise. We are doing business on an indeterminate permit under the Indiana statutes.

WHAT PROGRESS IS BEING MADE IN THE ADOPTION OF THE STANDARD THREAD FOR FIRE HYDRANT NOZZLES?

CHARLES B. YOBST: As I understand it now, we have what we call a national standard of 7½ threads to the inch which is adopted by all hydrant manufacturers and called the national standard.

DOW R. GWINN: Yes. Every city in Indiana now, with the exception of Indianapolis, has the standard nozzle. We held out for years because our nozzles were so close to the standard that a standard hose could be attached to the hydrant, but for the sake of uniformity we agreed with the inspection bureau to have them changed. We changed those nozzles on our hydrants and it was a very simple matter; the inspection bureau sent their men out with the adapters, a little device for cutting the nozzles to the standard, and he stayed with our men for one day, after that the men did it without any help. It took 104 hours for two men with a Ford to change 1245 hydrants. One man was paid 40 cents an hour and the other 45, and we charged 50 cents an hour for the use of the Ford. There are two nozzles to each hydrant. The average cost per hydrant was 13.1 cents. That put us in line with every city in the state except Indianapolis, so that if we have a serious fire and call on Fort Wayne or Vincennes or some of the other towns to come to help us out, their hose will fit our hydrants. It is worth while.

Answering Mr. Craig's question, the city paid for changing the hose threads. This same man instructed the city how to change the hose threads on the city hose and the city firemen did the work themselves, and then they went to the private plants that have fire hose and hydrants and did the same for them, and we took care of the private hydrants. The cost of changing hose threads would be less than on hydrant nipples, as it would all be done at the engine houses.

ISAAC S. WALKER: What about changing the threads on the steamer connections? That is a rather difficult procedure; 4 threads to the inch is the underwriter's standard, if I recollect correctly.

Dow R. Gwinn: I did not understand that there was a standard for the steamers.

Isaac W. Walker: Four threads per inch, as I understand. It is a comparatively easy matter to change the 2½ inch nozzles. We changed them at Greencastle. We had 8 threads per inch on the hydrant and they were recut to the underwriter's standard of 7½.

Dow R. Gwinn: Our fire department took two 2½ inch lines from the hydrant and connected up on each side of the steamer; not a Siamese connection, we take two 2½ inch lines and connect to the steamer.

(The National Standard included 2½-inch, 3-inch, 3½-inch and 4½-inch nozzles. The 4½-inch with 4 threads per inch. No tool has been produced as yet for changing the steamer or 4½-inch nozzles and there is no record of any changes to Standard of such nozzles. Tools for recutting 2½-inch nozzle threads to Standard when they are near enough for the purpose are on the market, made among others by the Greenfield Tap and Die Corporation, Greenfield, Mass. The set includes several tools, for cutting male and female threads and for expanding nipples that are slightly under size for recutting.—*Editor.*)

Isaac S. Walker: The inspection bureau just made an inspection at their plant in Vincennes and they recommended the adoption of the standard thread 7½ on 2½ inch outlets and 4 on the steamer outlets. I think we only have a few steamer outlets there and I think they are about 7 threads per inch. All our threads in Chester are 7 per inch; it is a pretty difficult proposition to get down to 4 per inch on those large outlets.

W. C. Hopper: I will say that the inspection bureau in Ohio just got through with the biggest part of Ohio; they are going back towards Columbus, and they tell me that when they get on that return trip, Ohio will be practically standardized.

PAINTING FIRE HYDRANTS: BEST COLOR FROM FIREMAN'S STANDPOINT AND FOR PROTECTION OF HYDRANT

CHARLES B. YOBST: We selected red with a white enamel top.

JAMES E. GIBSON: At Charleston we live in a salt atmosphere and paint is rather a hard article to deal with, particularly on iron, but the custom has been to paint red. Recently I began a study of the matter and in one of the periodicals, the Journal of the New England Water Works Association, I read a paper by Carlton E. Davis, of Philadelphia, giving the results of some tests he had made on various colors for hydrants, and finally stating that he had adopted yellow as the most distinctive color both by daylight and artificial light. With this information, I recommended to our Commission that we paint our hydrants yellow with a black band near the ground to take care of the discoloration due to splattering of dirt and mud during rainfall. This recommendation was adopted. We have painted, therefore, all of our hydrants an orange yellow in color and we find them to be very distinctive. One of our Councilmen, sometime after we had a number of hydrants painted in the business section, stopped me and wanted to know "Who ever heard of painting a fire hydrant any other color but red." My reply was "You will note in Charleston we have painted them yellow." He stated that he had never heard of yellow being the proper color for a fire hydrant, but he said, "To tell you the truth, I never knew we had so many fire hydrants in Charleston." One of our men, while painting a hydrant, was closely observed by one of our citizens and after the latter had watched the painter for sometime he turned away in disgust and said in an undertone, "When did our mayor turn Orangeman?" Yellow is a distinctive color, and as you drive around the city after dark in your automobile you can observe the yellow fire hydrant three or four squares ahead of you without any difficulty, and they stand out against the dark background. We had hoped that this distinctive color would reduce accidents from automobiles and joyriders, but we have about concluded that when a man goes out joyriding such a little thing as a yellow hydrant will not stop him.

ALEXANDER MILNE: How long does it stand up?

JAMES E. GIBSON: I have not had enough experience to answer that question.

ALEXANDER MILNE: Heretofore we have been using green throughout Canada; once in a while you will find a yellow one. Two years ago at the request of the fire chief, we painted red enamel by using a Chinese vermilion enamel with a yellow ground color to bring it out. After two years those hydrants looked like blazes, the enamel does not preserve them, it breaks off and even the lead paint does not stand. After a lot of experimental work I found that by using a standard green with 10 per cent graphite in the mixture, you get no condensation sweating at all, there is no discoloration; the hydrant will stand there five or six years without losing its color. True, you do not see them so well at night, but the firemen are supposed to know where every hydrant is, and it appears to me that the hydrant should be painted with the best preservative for the hydrant without particular regard to display. The white caps, I do not think much of, they look too much like Ku Klux outfits; my choice is the green with the graphite mixture.

G. W. BRISBIN: At Battle Creek for a great many years we painted our hydrants green, and that is the color that is best from the aesthetic standpoint. There is no question that it is a mar to the landscape to have a red hydrant, almost as much of an incongruity as shaking a red rag at a bull. At first the department did not like the green and they insisted on having the hydrant painted red, and while I did not like the idea, we conformed to their views because they are the ones that have to use them. I do not think they can stop to look at a blueprint when they go to a fire to see where the hydrant is—they are not allowed fifteen minutes to get ready.

W. E. MILLER: They are supposed to know where it is.

ISAAC S. WALKER: I might add just one word to Mr. Lamey's remarks on one point which influenced us somewhat in deciding to try out the yellow color for our hydrants in Chester. Quite recently the Pennsylvania Railroad adopted this color as the standard for all the signals on their entire system, tests, I am informed, having proved that this color may be more readily observed, both by day and by night, than any other color.

It was therefore believed worth while to try out this color on our fire hydrants, as prominence is desirable in order that firemen may readily find them at night. From this standpoint the color green is unsatisfactory when hydrants are located in grass plots and near trees or shrubbery. We selected the same shade, a brilliant yellow, used by the Pennsylvania Railroad. The color used by Mr. Davis in Philadelphia was more on the orange hue, or "pumpkin" color. The painting was done about six months ago, has held up well, and has caused no especially adverse comment.

R. H. STARR: As regards the painting of hydrants a yellow color, has any consideration been taken of that color in connection with the northern countries where the snow gets up two and three feet higher than the hydrants. How does yellow show on a snow background?

(Answer—Very good.)

If yellow is then such a good color why not go one step further and use a yellow luminous paint which should make the hydrant more prominent at night. Such a paint is made by an English firm and carried in stock in Montreal.

J. A. JENSEN: The color used on hydrants does not make any difference so far as protection is concerned. Red paint has been adopted in many places to make the hydrant conspicuous, but breakages are the results of accidents and placement of hydrants, in which color plays no part. To make a hydrant conspicuous it is important to get a permanent color if possible. Red and yellow both fade to a dirty white with variations. Green is the most desirable and durable color, especially in residential sections. Painted green with a red or yellow cap or dome the hydrant can be made prominent or conspicuous with as little maintenance as any painting scheme.

STEPHEN H. TAYLOR: At New Bedford we stick to the old dark green, almost black, but the fire chief does like to have the cap painted white to distinguish them at night. We have stuck to that color a long time, the only change being the addition of the white cap. One of our neighboring towns uses red and paints them every year, but the paint does not stand up at all well.

J. M. DIVEN: Almost any paint will preserve iron, fire hydrants as well as other iron surfaces, and a hydrant that is kept properly painted for display purposes will always be well covered and so

protected from rust. Fire hydrants are first of all for use, not for ornament and the aesthetic aspect should not interfere with the utility.

It is all well enough to say that the firemen should know where the hydrant is located, but with 500 or more hydrants in a city is not that too much to ask of a fireman? It would be ideal if the hydrants could all be located on the same corner, say all in a city on the north west corner of the street intersection, a fireman would then know just where to find them. But this would not help for hydrants in the middle of blocks or other points than street intersections. Getting to a hydrant and connecting up is a matter of seconds or even less, not of minutes. To stop a heavy piece of fire apparatus near where a hydrant is located, locate it exactly, start up again, maybe have to back or cross a street, takes precious time. If the hydrant can be seen by the driver, even approaching at full speed, so he can make a stop at the exact location it will save these valuable moments.

On a recent visit to Philadelphia I noticed that the yellow painted hydrants described by Mr. Davis looked dingy and were not easily seen in daylight, so I am doubtful whether that is going to prove the ideal color. I am inclined to think we have further to go.

I have used aluminum bronze and found it satisfactory from most points of view. It was easily seen both night and day, lasted well and was a good protection for iron. It was high in first cost, but outlasted anything I ever used before or since. These hydrants were painted over the old red without retouching or attempting to make a good ground. Probably a little more pains in putting on a good and light colored ground, would have improved them both in appearance and lasting quality.

To the speaker green seems the least suitable color. It is not distinctive in any situation, with any background and is not easily seen at night. It is especially hard to see, night or day, on residence streets where the hydrants are usually placed in the parking between the sidewalk and curb, where they blend with the green grass and are not conspicuous at night or day.

One other thought comes up in this connection. When the color is finally determined on it should be "patent righted," an ordinance should be passed prohibiting the use of that particular color for lamp posts, signs or other structures that might be confused with the hydrant. The hydrants should have their own peculiar color and mark so as to be quickly and easily seen, located in a hurry and confusion, as is usual when answering a fire alarm.

FIRE PROTECTION SERVICE OF THE WATER DEPARTMENT: SHOULD IT BE PAID FROM WATER RATES OR GENERAL TAX FUND?

Dow R. Gwinn: That is a question that the municipal people are all interested in. It does not make much difference to us private company men.

Lyman P. Hapgood: From the general tax fund. In fixing a water rate, whether it be a "flat" or a "meter" rate, it is contemplated that there will be used a certain quantity of water in a given period of time, and that the rate so fixed will produce revenue in a sufficient amount at least to meet the cost of production and distribution, maintenance, interest, sinking fund and depreciation.

In the matter of public fire protection, the quantity of water actually used has little, if any, part in fixing the proper charge therefor. The quantity so used often amounts to less than 0.5 per cent of the annual pumpage. But a plentiful supply must be always ready and available for instant use without notice.

To make such ready-to-serve conditions possible, special apparatus, as hydrants and reservoirs, are installed, and pipe sizes, pump sizes and water supply and filtration must be increased over and above those required for supplying the consumer with his requirements for domestic, commercial and manufacturing use. It is estimated that from 20 to 40 per cent of the total capital outlay in a water works system is for fire protection alone.

When the charge for fire protection is worked into the consumers water rate then he is obliged to pay not only for the water he has used and expects to pay for, but, in addition, he shoulders a burden rightfully belonging to another, who thus escapes that burden entirely, the non-resident property owner.

When the charge for public fire protection is placed in the general tax levy, where it justly belongs, every property owner, both resident and non-resident, especially the non-resident property owner, contributes his own fair share of the cost and upkeep of that fire

protection service which is one of the things that makes his property valuable and upon which he bases his rate for rents.

But when this charge is paid by the water consumer then the non-resident property owner, the value of whose property is greatly enhanced by the protection afforded, takes absolutely no part in its support though receiving its benefit.

Consequently, the only fair way to charge for public fire protection is by putting the charge into the general tax levy that all, benefiting by the service, may share its costs, and also that the water consumer's rate may be lower by eliminating that charge from them.

Dow R. Gwinn: This question is open for discussion. Perhaps you may agree with Mr. Hapgood; it sounds like good common sense to me.

P. J. Hurtgen: In the city of Kenosha our operating revenue was approximately $135,000 per year, and the matter of fire protection is fixed by the Railroad Commission. Last year we charged a part of the fire protection off in general taxes and the basis on which they arrive at the proper amount is something similar to what you have just read. That part of the system that is in excess of what is required to furnish water for other than fire protection. The way it works out in our city, with a population of about 45,000, is as follows: We have three pumping units and our daily consumption averages 5,000,000 gallons. We have three pumping units with a capacity of 6,000,000 gallons each, and, during the peak load, we operate two of the pumps; probably one only about an hour or two per day and some days we operate only one pump. Therefore, practically a third of our entire pumping system can be charged to fire protection, because we have that one pump in reserve all the time; and that ratio applies practically throughout the entire system with the increased size of mains and the increased pumping capacity. While the Railroad Commission allowed us $42,000 it should have been about $45,000, namely one-third of our operating cost which was approximately $135,000.

It amounts to about 33 per cent and I think that is a just charge to the city at large and should not be borne by the individual consumers. Now the Railroad Commission of Wisconsin have made some calculations by which they claim that in cities of about 60,000 inhabitants and below, about a dollar per capita per year is some-

where near the proper charge for fire protection, and that is about the way it works out in our city, our population being about 45,000.

In answer to Mr. Gwinn's question, we did take into consideration the larger sized mains necessary, for we could get along with smaller mains if we were not furnishing fire protection.

We took into consideration the increased size of the mains, pumping units and also the increased number of filter beds.

ALEXANDER MILNE: A few years ago the question came up before the convention and I kept some notes of the proceedings at that time and looked them over ten days ago with a view of speaking on this topic after our Chairman suggested it. I think we found at that time that, taking the average water works plant of the United States and Canada, the estimated cost for water supply on the total capitalization of the plants on the continent at that time was about 47 per cent for fire protection purposes over the capacity and equipment necessary for domestic use. It strikes me that it would be a rather hard matter for the majority of the municipal plants to induce your city councils to levy a rate for fire hazard, sufficient to produce 47 per cent of your total revenue. We found it so in our city. We finally compelled the city council to levy a hydrant levy charge of $40 per hydrant and we made them pay it. Recently we got into another fight on the same subject and the city revenues were rather depleted and ours were increased. Our financial situation was in pretty good shape and they cut our hydrant rental to $20 a hydrant, which is too small. I had very hard work to convince the members of the Board who thought we should collect that entire charge in water rents; our consumers were well satisfied with their rates and were paying them quite promptly, but after considerable argument I persuaded the city council that the fire protection charge should be collected from the general tax rates of the community by a levy assessed as an item on the tax roll for fire protection, whereby every individual property pays exactly in proportion to its assessment, and this fire protection benefit is supposedly in proportion to that assessment. Take two neighbors on the same street: one has a $25,000 house and the one next door has a $3000 house; each is paying exactly in proportion to his assessed value and the protection he gets from the fire department. I think it is the only way to levy that fire protection rate.

HENRY P. BOHMANN: I just want to confirm what the previous speaker said about the city council not permitting such a rate to go into effect. In the city of Milwaukee we at one time charged an annual hydrant rental of $3 per hydrant and it was never paid. The rate was later raised to $5 and occasionally paid. Now we have made it $10 and it is always paid. The charge of $10 just about pays for the hydrant inspection and maintenance. As to making a charge based on the excess cost due to increased size of mains to take care of fire protection, I think is a very debatable question. In the case of a large and growing city, the distribution mains should be large enough to take care of this growth, otherwise you would be digging up and relaying your pipes all the time; therefore, the size of the pipes you lay in excess of the immediate demands to take care of future growth should at all times take care of your fire protection which does not amount to anywhere near 40 per cent; in small towns, however, a water works is built primarily for fire protection, but in large cities, where every lot is built up and you have to build for future growth, you would be forever digging up your pavements, unless future growth is anticipated. We feel that the system we lay will take care of the future growth of the city even though a certain district may today have only small residences or large apartment buildings. We never notice even the largest fire at the pumping station; so when you speak about charging 40 or 50 per cent of your investment to fire protection, it may be true of small towns, but not in the case of a large city.

ALEXANDER MILNE: Replying to the speaker on that topic, the figure I gave of 47 per cent was the general average of all water works plants on the continent.

CHESTER R. MCFARLAND: This question seems to me out of place in this meeting. In the first place, the superintendents are unable to fix this rate. This is a very abstruse problem. There are three classes of people in each city; first, the consumer; second, the property-holder who has an improved property that has to be protected from fire loss; third, the person who owns vacant property and has no buildings to protect; the only advantage he gets from the water system is that he has a water main laid in front of the premises which makes it more valuable, in the same way that a business property is valued by the number of people who pass it during the business

hours of a single day; his property is made more marketable. The question has been raised as to the proper proportion to charge for fire protection. In the first place, you lay a main in a street; it is ample to-day to provide fire protection and to provide the public with all the water they want to consume; but, in five years from now, if that city is prosperous, that section will be built up and the consumption will grow to such an extent that the main that provided fire protection and water supply will not provide sufficient water for domestic purposes. Would it not have been fair to have charged the extra size of that main up to the public to protect their property? So it seems to me that this is a question with so many ramifications and so many details that it will take a thorough study of the whole subject to enable anything to be put before this convention that would be reliable, something on which you may base your report.

W. C. Brockway: Relative to fire protection service and hydrant rentals, the city plant at Duluth charges $50 a hydrant. This amounts to about $55,000 a year. The actual cost, however, amounts to approximately $110,000 a year for fire protection service, according to manager D. A. Reed.

Since 1918, however, the city has failed to pay the hydrant rentals. The Water Department does not pay taxes. It is informally understood by both the city and the Water Department that the hydrant rental charge amounts to the difference between the cost of rendering fire protection service and the amount of the local taxes. In Duluth a difference of opinion exists among the officials and interested citizens, as to whether the water department should pay taxes, and what taxes should be included.

Dow R. Gwinn: In our city, the plant is privately owned, our gross earnings last year were $334,000. Our taxes of all kinds, including federal taxes, were $67,000 or 20 per cent of our gross earnings. The city paid $60,000 for public fire protection, but they also paid for the water used in the schools and public buildings, so that practically the amount paid by the city just about offset the taxes.

James E. Gibson: In Charleston, South Carolina, we are municipally owned. We pay no county, state or federal taxes. The city pays to the Commission $44,000 per year for the first 600 hydrants, and $25 per hydrant per year for all hydrants in excess of 600. The

payment of $44,000 annually includes an allotment of 300,000 gallons of water per day for municipal purposes. This is where we get our fingers pinched, for instead of taking 300,000 gallons of water per day the city takes from 900,000 to 1,000,000 gallons and as there is no appropriation for this excess it is up to us by inspection and cooperation with the other city departments to keep this surplus water down to a minimum. If we had to pay taxes as Mr. Gwinn, I am afraid it would be a losing proposition. The gross revenue for water last year was $390,000. In addition to this revenue there is $30,000 revenue obtained from interest on the investment of surplus funds in the plant. The department pays all interest, depreciation, maintenance and sinking fund on the investment of $1,500,000 bonds, with which the plant was purchased in 1917. All monies are retained in our treasury and all improvements to date have been made from a surplus income. During the six years of municipal operation we have added something like $990,000 to the value of the plant, all of which, as before stated, has been paid out of surplus with the exception of a loan made by the National Government during the war period. This loan now amounts to $250,000, so while we do not pay taxes we are carrying the burden of the waterworks, and we are able to make all improvements without going before the people for bond issue.

George E. Chambers: At Buffalo we get $15 per hydrant per year for about 6000 hydrants which we maintain; we maintain the hydrants and furnish the water to that amount.

J. M. Diven: It is obviously unfair that a person with a property valued at $1000 and having a single faucet should pay as much for water, the rate including the fire protection water cost, as a large warehouse pays, which with its contents is valued at many thousand dollars and has a single faucet. The warehouse gets fire protection on a large property value for which the owner of the small house helps to pay.

How would the people of a city look at it, if the appropriation for the maintenance of the fire department, engine houses, apparatus, firemen, etc., were separated from the general tax and charged at a price per front foot? Yet this is exactly what many cities, where water rates are based on frontage, are doing. The water service for fire protection is just as much of the cost of maintaining the fire department as the payroll of the firemen.

DIRECT FIRE PRESSURE VS. PORTABLE PUMPING APPARATUS

Dow R. Gwinn: This question to my mind is one of the most important questions we have before us today. About a year ago Mr. Charles Henderson of Davenport, Iowa, one of the past Presidents of this Association, presented a paper which was published in the proceedings for July, 1922. He went into the matter very thoroughly by corresponding with the different cities to find out how many carried fire pressure. He found that the increase of pressure ranges from 4 to 55 pounds; the average is 24 pounds. In the large cities, such as New York, Philadelphia and Baltimore, high pressure hydrants, supplied by separate pumps, take care of fire supplies. The consensus of opinion seemed to be that in the larger cities they should not raise the fire pressure as it would be taking too many chances of bursting some of the mains and that it would be better to depend upon the ordinary domestic pressure, assuming it was 45, 50 or 60 pounds. He states that ordinarily firemen do not require more than 40 to 45 pounds pressure at the base of the nozzle. Large fires require more pressure than any water works can safely carry. The mistake, as I see it, has been made in many places of trying to get along with a few hydrants by using long lines of hose. That is very expensive and the friction loss is so great that much of the pressure is lost before it reaches the nozzle.

The city should be provided with pumpers to take care of any additional fire pressure that may be necessary. In a talk with one of the officials of the Board of Fire Underwriters he expressed the opinion that, in a city of 50,000 or larger, pumpers or fire engines should be provided to take care of the pipes.

Thomas Healy: At Davenport we raise the pressure on the upper level. We carry a pressure of 45 pounds and at time of fire we increase it to 70, and on the lower level we have a domestic pressure of 65 and raise it to 110. Every time we make those changes, we burst service pipes, the plumbing in houses, and often break mains. If you break a main at the time of fire, you haven't much fire pressure

and it is a very dangerous proposition. The simple remedy is to lay mains larger and provide a distribution system to take care of fire service. We have a reservoir at which the static pressure on the lower level is 65 pounds from our reservoir head. If we did not have to provide fire protection, we could lay smaller, lighter mains and it would not cost so much to construct the plant or so much for upkeep.

STEPHEN H. TAYLOR: At the convention of the New England Water Works Association last fall a paper was read by one of the National Board of Underwriters and his summing up was, as I recollect it, that the water works should not be required to raise the pressure, but portable pumping apparatus should be provided for the reasons outlined in the paper you have just read, that it entailed an unnecessarily heavy expenditure for larger mains, that the same expenditure in portable pumps would do a great deal more good. In New Bedford we have a pressure varying from 14 on the hill to 90 pounds at the water front. I notice in every case, even if the fire is down at the water front, the fire department connect their pumpers, and it seems from the experience in our locality that the pumpers are less expensive than the extra expenditure in the water system for larger and heavier pipes.

ALEXANDER MILNE: I do not think there is a great deal to debate on this question looking at it from the ordinary water works point of view. We have had several papers recently. Mr. Jensen's paper was a very good one, I think the best I have heard, as between the direct fire pressure and the pumper service, given this forenoon across the river at Windsor, at the annual meeting of the Canadian Section. By the way, we have got 200 members now over there and we are holding two meetings a year. I am only sorry that more of our members were not over there to hear what we were doing. Mr. Jensen of Minneapolis gave us a most excellent paper on this subject of pressure, which will be published in the engineering press and in the JOURNAL of the association. I recommend that you read that paper; you will find it the best paper on this topic.

G. W. BRISBIN: We carry unusual pressure in Monroe, Mich.; we carry from 60 to 90 pounds pressure ordinarily in all except a very small portion of the city, which gets about half the pressure; in other words, it is about a hundred feet above the level of the business portion

of the city. We do not find any trouble from the excessive pressure as some people would call it, because it serves a great many purposes. For instance, we have a machine for cleaning sewers; that machine becomes stalled once in a while; in our neighborhood we have only half the pressure carried by most of the city, and unless we had a direct pressure system, we could not operate that machine successfully in a great many cases. People like the high pressure because the sprinkling is better. I do not think there is much danger of the bursting of pipes, because we have two pumps at our well stations and they run as high as 120 and even 122 pounds pressure and have never burst a pipe as far as I know. We use extra heavy lead pipe in the street for small services, and galvanized standard pipe in the buildings and yards. It seems to me that a water pressure should give a pressure that will answer the purpose best, and you cannot get any more pressure for that because no city, or at least almost no city, is on a dead level or nearly dead level. In spite of all the protest made against high pressure and against the use of pumping engines, I think it would be better to increase the standard domestic pressure as it is ordinarily called rather than decrease it, and while we have two fire engines, we had none for a considerable time and the chief of our fire department said he would not want a bit more pressure than he has in the lower part of the city for any ordinary fire. When it comes to a fire in an eight or ten story building there must be more pressure, and there we have pumping engines; our neighbors think we are all right, that we have the best end of the matter of pressure, and I believe they are pretty near right. While it is expensive, it is a really good thing to be able to furnish people with water at a good strong pressure as we have in our city. We use class B pipe.

Isaac W. Walker: I agree with the last speaker that a good pressure is certainly to be desired in a water works distribution system, but there are limits beyond which it is unreasonable and unnecessary to go. I should say an average pressure of about 70 pounds is to be considered excellent and generally satisfactory for all usual purposes, other than fire protection for the higher buildings.

The dependence upon increasing the pressure on the system to a 100 or more pounds for fire fighting purposes, is unsatisfactory, and I believe it is becoming pretty generally recognized. Many comparatively small towns now have their pumping apparatus. In an Indiana city, which one of our plants serves, a town of about 18,000,

it was the practice up to a short time ago to require us to cut out our standpipe and raise the pressure by direct pumping, to about 105 pounds when alarms of fire were sounded. Following the recommendation of the Insurance Inspection Bureau, and the demands of several Civic Associations, they recently purchased two pumpers, which eliminates the necessity for increasing pressures. Such increases are the cause of leaks in the street mains, in service pipes and house boilers.

Where direct fire pressure is used, the size and condition of the distribution system is a factor. A direct pressure of say 100 pounds may be satisfactory and give good service in a comparatively new piping system, of adequate size pipes, whereas the same pressure, on an older system with pipes badly tuberculated, and of small sizes, would be inadequate for fire purposes.

When pumping apparatus is used, the question of whether the pressure on the hydrant is 50 or 100 pounds is, I believe, of no moment. Up to a certain point the pressure on the hydrant, of course, reduces the amount of work to be done by the pumper. But the pumper should be of adequate capacity to deliver its quota of satisfactory fire streams under all pressure conditions, so that it is the job of the water works man to see that there is sufficient pressure available to deliver the required amount of water through the hydrant to the pump. Whether this pressure is 10 or 100 pounds is of no consequence, as long as the water, in sufficient amount, is there.

George H. Chambers: At Buffalo we are laying a new high pressure line in the business portion of the city at an expense of $200,000 and will furnish a pressure of about 250 pounds at times.

James E. Gibson: I think the damage occurs at the close of fire rather than at the beginning. Your engineer, upon receipt of the fire alarm, shuts off the stand pipe and raises the pressure. He gets the machinery and column of water moving at a pretty good rate of speed during the interval of fighting the fire and toward the end the fire marshal decides that he has got the fire under control and begins to order streams shut off. The rate of shutting off the streams depends somewhat upon the training and experience of the fire department, but usually without any sense of proportion or rate of speed that the water is being delivered, and the first knowledge that the pumping station engineer has of this condition is that his pumps are

stalled due to excessive pressure and this is when the damage is done to pumps and piping.

Charleston is situated on a peninsula, the average elevation probably does not exceed 15 feet above mean tide. Our pumping station is located some 14 miles from the center of distribution and the greatest elevation within forty miles would probably not exceed 50 feet, so that we are compelled to use the direct or Holly system. We aim to carry from 35 to 40 pounds on the street mains at all times, and, therefore, the fire department never responds to a fire call without carrying a pumper. The entire question, in our opinion, is one of economy, and certainly with the improvements in the fire engine, gasoline driven engines and pumpers the economy is on the side of the pumper, for by its use the investment on mains may be reduced and the damage and liability of damage due to the increasing of the pressure on the pumping system is entirely eliminated, as the fire chief has all the pumping apparatus under his direct supervision and nothing that he can do with a pumper will, under ordinary circumstances, have any effect upon the pressure in the distribution system.

Dow R. Gwinn: We pump against about 70 pounds ordinarily, and when the fire bell rings we raise it to 125, and in these days of motor equipment, it does not take the department long to get to the fire. They want the pressure about day before yesterday and we have to hustle to get it up. The worst feature is the effect on private consumers when supplied by meters. We are 98.7 per cent metered, and when we have had the fire pressure on a considerable length of time, during that month the water bills will be considerably higher, due to the fact that water closets which are adjusted to the domestic pressure, start running; so it is bad for private consumers.

EFFECT ON PIPES OF VARIOUS SOLUTIONS USED TO CLEAN WATER SERVICES: OTHER METHODS OF CLEARING CLOGGED WATER SERVICE PIPES

No member present had had any experience with any solution for cleaning service pipes. Mr. Dow R. Gwinn stated that he used a stiff wire to loosen deposits. Mr. Charles B. Yobst used a force pump and got good results, he did not dig up at the main, but pumped from the meter connection. Asked if the force pump would clear lime deposits, Mr. Yobst stated that the water he was supplying was soft and the deposits largely vegetable. He also said that in lead pipe the lime deposits were not hard and were easily forced back into the mains.

Joseph A. Hoy: In Worcester we use cement lined pipe for houses and other purposes up to $1\frac{1}{4}$-inch pipe, all the pipe lined by our own men. The pipe itself practically never shows any corrosion. Corrosion shows at tees, inside wall and at gooseneck and corporation at main. On relieving of pressure we run $\frac{1}{8}$-inch gas pipe rods out to the gooseneck, cleaning the service thoroughly, should there be corrosion at any couplings. If we do not get satisfactory pressure then, we take a small wad of toilet paper inserting it into the service pipe, and then attach a Blake & Knowles force pump forcing the wad of paper through the service until we have pressure on the pump of at least 5 or more pounds more than the pressure on the main at that point. When we have the pressure on the pump at the point that we want to force the wad through the corporation stop, a man will open the stop at the main and with the wad of paper and the pressure up to the stop at main it requires very little pumping to force the wad through the corporation cock, where it will dissolve in the main. After that is done owners have an ample supply at meters for a number of years again. We have been cleaning service pipes for a number of years in this way with perfect results.

Dow R. Gwinn: Answering the question as to the remedy, put in a new service and use genuine wrought iron pipe of some kind, but do not use steel pipe.

CHECK VALVES ON SERVICES: LIABILITY FOR DAMAGES TO HOUSE BOILERS CAUSED BY THEIR USE AND ADVISABILITY OF USING THEM. DAMAGES TO METERS FROM HOT WATER WHEN NO CHECK VALVE IS INSTALLED

ALEXANDER MILNE: We put a check valve on every service where there is a hot water connection, to protect the meter. In twenty years experience I have had no trouble with hot water boilers. The water is quite hard. We have had no explosions. If we shut the water off, we notify the householder or consumer, if it is a commercial consumer or manufacturing plant, to protect his boiler plant while we have the water shut off; we tell him of the probable duration of the shut-off, and in twenty years we have had no boiler trouble. We take the trouble to notify no matter what time of day or night water is turned off. If it is a commercial plant or steam boiler, there is always someone in charge. In the case of a boiler or a steam plant, where they are running steam pressures, we require relief valves.

FRANK LAMEY: We had one experience of check and relief valves at Chester, Pa., at the plant of the American Visco Company. They are in a suburb of Chester, a model village, and we thought that would be a good place to try out our installation of check valves, so we put a check valve on each property built in that model village, and shortly after blew up two tanks. The reliefs did not work. We took some of them off and took them to the pumping station and tested them out, put pressure on them, and probably once in ten tests the checks released at the proper pressure. We became afraid of them and we have very little trouble with hot water since discontinuing them. Once in a while we have a meter burned out with hot water and we simply repair the meter and bill the tenant or the proper person for the repairs to the meter.

WILLIAM R. YOUNG: We have never used check valves in Minneapolis, but in one case a few years ago, there was a cement factory that did. After getting several bills from me for meter repairs, they put a check valve on their plant, and about the same winter an attorney

called on me and asked why we put the check valve on, as the water had blown up and killed a man, and we would be subject to damages on account of the loss of life. I immediately asked him if he would show any information he had from the Water Department that it was necessary to put a check valve on that way, as we never gave any orders to put a check valve on, because we were very much afraid of them. He said it had been necessary for them to pay for repairs on hot water injured meter discs for a number of months. I told him the only way I could see to get rid of the cost of hot water injured discs would be putting in a larger pipe from the meter to the water tank, and they would get away from the hot water on the disc. We never recommended a check valve to anybody, and would not on that occasion, and my suggestion would be to put more pipes, even if coil pipes were used, between the meter and the hot water pipes, and main pipes, and get more water there, and I do not think you would have any trouble with the discs burning out.

Dow R. Gwinn: I do not want to take chances.

James E. Gibson: My experience has been that there are usually enough leaks to take care of the excessive pressure. I lived in one of the suburban towns of Philadelphia for a number of years where I had a check valve on my service pipe, and a spring relief valve on the hot water boiler. The only objection I found was that at times, particularly on wash days, you might occasionally get hot water from the cold water spigot, and I have found the relief valve popping, discharging small quantities of water on the floor. A good quality spring relief valve with a metal seat, I think, gives little trouble, especially if it is set near the main pressure so that it will pop occasionally. This relief valve should be practically of not less then $\frac{3}{4}$-inch size.

At present we do not have much trouble from the hot water backing into the meters, but when it does we bill the consumer for the cost of repairs. At the first instance of trouble we do not press the bill, but if the trouble occurs a second time we insist upon the bill being paid or otherwise we will discontinue the service. At the same time we insist upon a check valve being put in with a relief valve to prevent future trouble. We have had no difficulty from the check valves, but we did have one experience due to a break in the main; a hot water boiler collapsed due to vaccum. When the water was turned on again the boiler resumed its former shape and as it

showed no break or leakage the party made no claim. In another case, similar to this, the boiler did not go back in the former shape, and the Water Company (then privately owned) bore a portion of the cost of repairs.

ISAAC S. WALKER asked if any of the members who had installed check valves had had any trouble with chattering in the valves, stating that at Chester, Pa., they had had some such trouble.

MR. GWINN and MR. GIBSON said they had never heard of chattering check valves, but had had trouble from that source with water meters. A member stated that he had had trouble with chattering when using upright checks, but none with swing checks.

STEPHEN H. TAYLOR: It seems to me it all depends on getting a good relief valve. In New Bedford our rules call for relief and check valves in every installation. We have had some experience with collapsed boilers, but I think we have had more trouble from lack of check valves than because of them. The whole question is to get a reliable relief valve.

CHETWOOD SMITH: I have seen over thirty-five explosions resulting from over heating water, due to either check valves or stoppages, such as the valve being shut off between the range boiler and the service main. The force of those explosions no one can realize who has not seen them. A 50-gallon boiler raised to a temperature of 290 degrees has as much energy, as 1½ pounds of nitroglycerine when the explosion occurs, and I think very few people realize the force of the energy they are storing up. If it were not for water closet tanks and the fact that fortunately those water closet tank valves are so light they often cause trouble and complaint, the number of explosions would be a hundred times what they are today.

DOW R. GWINN: You are right.

ALEXANDER MILNE: I am free to admit that where the water is shut off without giving notice to the consumer, there may be trouble, but why should that be done? Except where your main breaks, there is no occasion to shut the water off without notifying the consumer. With a reasonably well equipped relief valve, your condition is taken care of entirely. During the last winter in one of our club

houses, we had a high pressure heating system, which was put on meter last fall for the first time, and inside of one month the discs and gears of the meter were burned out five times. I put a check valve on and three days after the check valve was put on my meter inspector, who happened to belong to the club, went in and looked at the meter and it was not going; it was burned out again; the check valve did not hold. So then I said "We will put a relief valve on," and I ordered one from a firm with a Canadian Agency, made for an 85-pound blowoff, an $1\frac{1}{4}$-inch one. Two days afterwards, the meter was still burned out. The inspector came over and told me. I said, "Have your father (who was general foreman) take that relief valve out and take it to the shop and test it." It blew off when he put the hydraulic pump on it at 280 pounds.

Chetwood Smith: I think that is the trouble with your check valve, you can build up any pressure on the service side; the relief valve is the most serious question. There is no relief valve now built which meets the requirements of the Boiler Code Committee of the American Society of Mechanical Engineers, because there is no relief valve built that is a true diaphragm in principle, designed to be attached directly to the pressure boiler. Generally they are on the principle of opening a small waterway for the relief. One of the most advertised valves today has an 8-inch relief, a Monel metal seat and rubber packing. The rubber packing will vulcanize under temperature onto the Monel metal and it takes four pounds actual strength to break that adhesion. You will have 256 pounds excess pressure before that valve will open, because the ratio of the valve is 64 to 1 against the pressure.

J. A. Jensen: One of the troubles mentioned is caused by placing the hot water coil in the fire instead of above it. Deposits are made in the pipe because in heating the water it is raised to boiling temperature. When water boils, lime and other deposits are made in the coil so that it finally becomes clogged, thereby interfering with the production of hot water and finally burns so that it must be replaced.

Hot water may be obtained by exposing a longer coil above the fire. With sufficient heating surface water will be properly heated without reaching the boiling point which causes deposits in the coil and back pressure in the tank. Under these conditions a generous supply of hot water is available without troubles from deposits or clogging. No check valve is needed and the meter is therefore safe against damage from this cause.

CLOGGING OF INTAKES BY FISH[1]

JOHN N. CHESTER: I do not believe that those conditions under different circumstances would apply. From my own experience in Lake and River intakes, and with Lake intakes I may name Ashtabula, Ohio and Sheboygan and Marionette, Wisconsin, and Erie, Pennsylvania, we were not and never have been seriously troubled with fish. In investigating this question once on building an intake at Ashtabula, I, like Mr. Metcalf, submitted the question to an expert along the fish line, and the theory was rather that the Lake fish, or at least their spawn, and minnows, inhabited the shallower and warmer waters along the shore, and while we have had trouble, with the short intakes, with filling our pipes with minnows, if we go 1000 to 1200 feet out into the lake and put in a submerged intake, this is absolutely overcome. That intake is about the same as Erie and Marionette and Sheboygan, where they have no trouble with fish. Of course, along the Ohio and Allegheny Rivers the acid takes care of that question, because there are no fish.

FRANK A. MARSTON: There were no eel troubles at this place. I have seen them elsewhere, but this particular intake is only troubled by smelts.

E. E. DAVIS: In our case there is no trouble at the intake, but small fish go through the screens at the entrance of the conduit supplying the pumps. The only trouble we have is in their going through the pumps, both centrifugal and plunger.

These fish are chopped up and they get in house connections and meters, thereby causing a bad as well as a fishy taste. As an old lady remarked to one of our inspectors, she was very fond of fresh fish, but did not like them in her drinking water.

A. U. SANDERSON: The experiences that Mr. Metcalf described at Portland, Maine, could be overcome by the installation of travelling screens. At Toronto the stationary screens were blocked at intervals by debris of all kinds during storm periods and by frazil ice during severe winters.

[1] Discussion at Detroit Convention, May 24, 1923, on paper by Mr. Metcalf. See JOURNAL, July, 1923, page 595.

The stationary screens were made in sections, 3 feet 3 inches by 4 feet 5 inches, and consisted of 4 mesh, No. 16, B. & S., copper wire, the water area being 63.5 per cent of the gross wire area. The velocity of water through these screens, at mean lake level, for the maximum demand of 65 million Imperial gallons, is 0.93 feet per second.

The travelling screens were installed in existing tanks, and are smaller for that reason than is desirable. The baskets have $\frac{3}{8}$-inch square openings of No. 12, B. & S., copper wire, the water area being 66.4 per cent of the gross wire area.

The velocity of water through the screes at mean lake level, for 65 million Imperial gallons, is 2.4 feet per second, and the velocity in the 72 inch conduit is 4.3 feet per second.

There are three kinds of ice that trouble water works men, anchor, floating, and frazil ice. The first will form on the bottom of streams and lakes, particularly on steel or iron, and will easily block small openings. Floating ice gives little trouble except in intakes of large capacity, laid in shallow water. Frazil ice is the most dangerous as it may occur anywhere between the bottom and the surface of the water and will block screens very quickly.

Travelling screens, motor driven and equipped with a hot water jet, will overcome difficulties with frazil ice.

Stephen H. Taylor: At New Bedford we have had quite a lot of trouble with fish in our screens. Our screens are at the outer end of our intake pipe, about 600 feet from the shore. We catch herring mostly and some smelts and eels. The tendency of a fish near the salt water is to follow the stream up and over fifteen miles from salt water we get the salt water fish. They travel against the flow of the water and that brings them naturally to the pond. Many times we have had to shut down our pumps on account of fish. We now have a revolving screen, and at times we have to run pretty slowly even with that. It is a common trouble, I think, for places within twenty miles of salt water. We have also had trouble with eels in pipes. They go through the eight mesh screen when they are very small, growing larger in the mains and finally get in to the tap, stopping it completely.

A. V. Ruggles: I wish to mention a roughly made intake crib which we installed on army work at St. Nazaire, France, for a 24 inch pump suction. Our crib consisted of a timber box with boards

covering about 50 per cent of the area of the sides and filled with broken stone. From this station we pumped through a line three miles long to a filtration plant, and one night I was notified that water had stopped coming through the line. I went over immediately and although it was dark I knew from the odor what the trouble was before I could see anything, as the 24-inch line had become completely blocked at the bends by eels.

At Cleveland we have had no trouble with fish. At the shore pumping stations we have $\frac{1}{2}$-inch mesh screens and at the open equalizing reservoirs inland we have screens with openings $\frac{1}{4}$-inch one way and several inches the other way. When these basins are cleaned we find a good many fish and crabs, and in one instance we found a basin, emptied the first time in fifteen years, contained a carp which well filled a wheelbarrow.

FLUSH HYDRANTS IN CONGESTED CITY STREETS

Caleb Mills Saville: The question has been brought to my attention by the complaints of several of our local shop keepers in narrow and congested streets. They say post hydrants are a nuisance and annoy people. Some of the other city officials have heard of flush hydrants, hydrants under the curb, and that they have been successfully used. Boston used to have some. Providence has some now, Salem, Massachusetts, had some until they had a conflagration and then they abandoned them, I think. They are very unobtrusive because they are under the sidewalk and annoy no one except the firemen on cold, stormy days. As I say they have been used in several places, and it will be interesting and instructive to know what the members here think of flush hydrants. Insurance interests have little use for them, and as far as I am informed, water department officials generally are not at all favorable to their use.

Dow R. Gwinn: We had an experience with flush hydrants many years ago. We had nineteen flush hydrants or underground hydrants in a pit with an iron lid. We had a great deal of trouble due to water hammer in the closing of those hydrants. They seem to jump on the thread of what would be about 25 per cent of the opening, and the result would be a plug in the neighborhood blown out. That happened a number of times. Then the firemen complained about them. The result was that we took everyone out and put in post hydrants instead.

Stephen H. Taylor: In New Bedford we had a great many flush hydrants and they were a source of trouble until we got them all out. Whenever there is snow on the ground or when they are covered with mud, they are hard to find, and from our point of view they were very unsatisfactory. We now use post hydrants only.

John G. Valentino: If the gentleman would not mind giving a little detail, what does he mean by flush hydrants?

CALEB MILLS SAVILLE: The flush hydrant was known as the Lawry Hydrant at one time, I think. It is a supply pipe coming off from the main into a brick chamber and up to within a few inches of the surface of the ground, controlled by valves. The chamber having an iron cover over it. That hydrant may be, as in some of the hydrants in Boston, right over the main itself, so that you can get a tremendous volume of water from it, or a lateral may be run to the sidewalk and controlled by a valve in the street. The fire department comes on a fire call, takes off the cover and screws on what is known as a chuck or hydrant head weighing from 100 to 125 pounds and then it is ready for the attachment of the hose. Each of the outlets are governed by an independent valve. This flush hydrant of course has a very great advantage because of the large amount of water that can come from it.

THE USE OF 4-INCH LATERALS AND HYDRANT BARRELS IN COUNTRY DISTRICTS

Caleb Mills Saville: That also is a question which was thrashed out quite a bit by the committee who functioned with the committee of the National Board of Fire Underwriters. If you are familiar with the rate book of the National Board, you will note that 4-inch pipe and also hydrants 4 inches in size are penalized. The question I had in mind was how the members of this Association feel in regard to the installation of those smaller sized mains and hydrants in outlying districts where otherwise there might be no water at all. There is no question about the effect on fire fighting, but is it better to have no pipe or water supply, if the return for a number of years will not justify the larger sized pipes? And where the balance comes between a sparsely settled community where water supply is the first requisite and fire prevention perhaps a secondary one. There are many small communities and large ones too that have a great deal of 4-inch pipe in their systems, and if they did not have it it seems to me there would be obstruction to civilization and progress.

Stephen H. Taylor: I once had occasion to test a hydrant in a long line of 4-inch pipe at a factory which was insured by the Factory Mutual Insurance Company for which I was inspecting. This factory notified the company that a public water system carrying 150 pounds pressure had been extended to their property, and asked credit for it in their insurance rate. We made the test and found that, although the static pressure was 150 pounds, the flow through 50 feet of hose using $1\frac{1}{8}$-inch nozzle reduced the pressure to about 15 pounds. With a $1\frac{3}{4}$-inch nozzle on the hose the water just barely ran out of the nozzle. In other words, the hydrant was of practically no use for fire protection. The difference in cost between a 6-inch pipe and a 4-inch is so little as compared with the greater amount of water delivered, that it is well worth while to install nothing less than a 6-inch pipe.

STEAMER CONNECTIONS (4½-INCH) ON SUPPLIES HAVING HIGH PRESSURE, 75 POUNDS OR OVER. ARE THEY NECESSARY OR REASONABLE?

W. C. Hawley: That is a question which I should like to have answered. I am up against that proposition right now. I have taken the position that, with the ordinary fire hydrant, with 2½-inch hose connections, with pressures as in our case of 125 to 175 pounds, the 4½-inch connection is unnecessary, and worse than that, dangerous. If a steam fire engine or motor engine is attached to a hydrant under those pressures, I am afraid it might shake the hydrant off the lateral. One of the municipalities we serve demands that we set some hydrants with a steamer connection. I explained why I did not want to do so. They insisted and I said, "If you will assume the responsibility for any accident that may happen, including the financial responsibility for the damage if a hydrant blows off, we will set the hydrant with a 4½-inch connection." We had an order the other day to set the hydrants with 2½-inch connections and one is already in. In one division where we expect the pipes to be taken over before very long, we are setting some of these hydrants. There are a number in service. We have had no serious trouble with them, but frankly I am afraid of them.

President Cramer: I might state in my own case that, upon the introduction of motor apparatus, the question of large openings for pumper connection came up, the city paid for the first 20 hydrants with steamer opening and with this an agreement was made that the maximum pressure of 120 pounds be reduced to 90 pounds and that pumpers be used for all extra strong streams needed or for very large fires. We have found that it saves a considerable time in getting a pumper to work where the large suction is used rather than the two 2½-inch hose connections and is much more satisfactory to the Fire Department. After three years of use we have found no objection to their use. I should not consent to the use of the large suction in Mr. Hawley's case or for any pressure in excess of 100 pounds. The city in any case should pay for the added expense in furnishing the steamer hydrant.

W. C. Hawley: Since this matter came up, we have had an interesting test made. One of our politicians for some reason conceived the necessity of making a fire stream test. He was not sufficiently courteous to notify the Water Company that he was going to pull this test off, but he did notify the County Fire Marshal and some of the newspaper reporters and told the latter that there would be "something doing." He went into the thickly built up business district and on a block 800 feet long, six fire streams were thrown with one more taken at a distance of about 300 feet, making seven streams in all. The hose lines were 350 feet long, with the exception of one which was 500 feet. $1\frac{1}{8}$-inch nozzles were used, except on two streams on which $1\frac{1}{4}$-inch nozzles were used. They did not take the pressure at any of the fire hydrants before or during the test, but did take the pressure at the nozzles of each of the seven streams. Under these conditions, the pressures at the nozzles varied from a minimum of 55 pounds at the nozzle at the end of 500 feet hose, to 80 pounds at one of the $1\frac{1}{8}$-inch nozzles.

They then put the motor pumper on a fire hydrant diagonally across the street from the hydrant to which they had attached the 500 feet of hose and took water from one $2\frac{1}{2}$-inch nozzle and delivered it through three lines of $2\frac{1}{2}$-inch hose, each 100 feet long, to the turret on a chemical truck which was equipped with one $1\frac{3}{4}$-inch nozzle. With this additional draught on the system the pressures were again taken at the nozzles on the seven streams before referred to. On the stream taken through 500 feet of hose the pressure was reduced to 40 pounds. The pressures on two of the other streams were reduced from 60 to 52 pounds and from 68 to 58 pounds and the pressures on the other four remained the same as they had been before the pumper was started.

Because the pressures at the nozzles were from 40 to 80 pounds instead of 150 to 160 pounds, the static head, the newspaper reporters were told how inadequate the fire protection was and the public was informed by the papers that "millions of dollars worth of property and hundreds of lives were jeopardized by inadequate mains and pressures." Of course a reference to Freeman's tables and to the tables of the Underwriters demonstrated how wrong the conclusions were which had been reached and the newspapers promptly published a correction.

The interesting point about the test was that, while there was ordinarily a static pressure of 149 pounds on the hydrant to which

the pumper was attached, when the pumper was run for the first time, there was a pressure of about 40 pounds on the suction side with the pumper running. They then shut it down and closed the fire hydrant. Orders were then given to start the pumper again, but upon starting up no pressure was indicated on the suction side until one of the employees of the Water Company, who happened along, opened the fire hydrant properly and there was then a pressure of 100 pounds on the suction side with the pumper running and, as stated before, supplying three lines of 2½-inch hose through a 1¾-inch nozzle. The pressure on this nozzle while the water was being drawn was 74 pounds, which indicated a little less than 800 gallons per minute and with the other seven streams, there was a total amount of almost 3000 gallons per minute being drawn.

This test would seem to indicate, at least for pressures of 150 to 160 pounds, that a 4½-inch nozzle on a fire hydrant is not necessary and in fact that a pumper or fire engine is not necessary. If some accident happened and the pressure was materially reduced in the mains, the difference between a 2½-inch suction and a 4½-inch suction would be but a matter of a very few pounds. Undoubtedly, in the case of distribution systems where the pressure is comparatively low, fire hydrants should be set having the larger nozzles, but where the water pressure is high and the danger of accident to the hydrant is materially increased by the vibration of the pumper, there are serious objections to the use of the large nozzles, especially when we consider that the maximum effective suction lift which can be exerted is only a matter of about 10 pounds.

A short time after the so-called "test" was made, we had a real practical test at a fire which occurred in a large building in the same block. The fire had obtained a good start and was so threatening to adjoining property that the fire department of the city of Pittsburgh was called out and also the County Fire Marshal. Seven fire streams, the same number as used in the "test," not counting the pumper, were in service and the fire was put out within half an hour. Our company took occasion through advertisements in the local papers, to call attention of the public to the first test and its "results" as stated by the men who made it and the actual results obtained at a real test where a bad fire was extinguished.

NORMAN R. WILSON: With regard to the large sized opening for pumper connections, I have had a good deal of experience in testing

engines under all conditions, and I consider it is entirely unnecessary to have the large steamer connection in a hydrant, or rather to alter the hydrants that only have 2½-inch openings. The way to do that is to have a reducer on the large suction hose of the engine in order to attach it to one of the 2½-inch hydrant opening. You can then get as good a volume of water as you can with the large hydrant port. The short reduction to 2½-inch opening does not decrease the flow, it simply increases the speed at which your water comes through.

You cannot, however, get the same results by connecting the engine suction to the hydrant by means of two 50-foot lengths of hose to the two sides of the hydrant as the friction due to the long lengths of hose considerably reduces the flow and further the ordinary hose is not a suction hose and is liable to collapse should the pump suction pressure be in excess of the discharge pressure at the hydrant.

I would certainly not advise anyone to go to the expense of altering existing hydrants to those having steamer openings. It is simply a waste of money. Of course, if new hydrants have to be put in, the special large steamer opening should be provided as it saves attaching the reducer to the engine suction.

James E. Gibson: My experience does not cover 75 pounds pressure on distribution mains as we only carry about 40 pounds. Our chief of fire department specifies steamer nozzles for all hydrants. We put them in, however, in the business sections only or where we consider that in future they may be needed.

Our fire department pumpers carry the full size hose for the steamer nozzle, but, as the last gentleman stated, this hose is fitted with a reducer to fit standard 2½-inch nozzles, and, without exception, the firemen always connect to the 2½-inch nozzle without regard to whether the hydrant has a steamer connection or not. With 40 pounds pressure on the mains I have yet to see them pull a vacuum on the suction of the pumper.

G. E. Shoemaker: At Waterloo, our fire department is equipped with motor pumpers. Nearly all of our hydrants in the downtown districts and in the large fire districts have steamer connections, but I do not believe that in the nineteen years I have been in Waterloo, there has ever been a hose attached to these steamer connections. The fire department uses the two 2½-inch connections.

I think, however, that the Board of Fire Underwriters might possibly make some objection if we did not have the 4½-inch connection, and I think one of their recommendations was that the fire department be equipped to use the steamer connection if necessary.

J. W. McEvoy: At Dubuque, Iowa, we carry a pressure that varies from 85 to 125 pounds. We have 4½-inch steamer connections on practically all our hydrants, and the fire department uses the 4½-inch in every case and never have any trouble, even with the 155 pound pressure hydrants, from a hydrant blowing out or getting out of order.

A. S. Holway: We place nothing but hydrants with steamer connection, and our fire department uses them invariably. We feel it is worth the small extra expense. We have had no trouble, although we carry pressure as high as 125 pounds.

George F. Merrill: Replying to Mr. Hawley's statement as to the liability of hydrants blowing off the connecting pipe where under high pressure, and the inference that the standard 4½-inch steamer connection causes somewhat greater flow of water than the standard 2½-inch hose nozzle, thus tending to more severe water hammer on closing of hydrants, I believe that it is good practice to strap hydrants on or brace them securely, whether steamer connections are used or not, in cases where water pressures run high enough to create any liability of their blowing off. This is very essential as insurance against water damages to private property arising from any breaks of this nature; and also well worth the slight expense required in preserving the continuity of fire and domestic service.

As to the use of steamer connections, the added expense is small, only about $3 or $4 per hydrant if hydrants are ordered so fitted. The steamer connections are recommended by the underwriters, and undoubtedly add to the efficiency of the fire department through the use of standardized connections. They furnish water also with the minimum amount of friction loss through the hydrant.

John N. Chester: Mr. Holway's statement puts me in mind of a question that I believe some one down in Tennessee wrote to a mail order house in Chicago, describing a piece of timber he had, and wanted to know the price of a sawmill to cut it up, and they wrote back to

him that a sawmill for that purpose would cost $2500, and he replied "If I had $2500 what in hell do you think I'd want with a sawmill?" And if Mr. Holway has 125 pounds pressure, I would like to know what he needs with a steamer connection?

A. S. Holway: That was on our old high pressure system, which has been amalgamated with the regular system. We now carry 80 pounds. That was put on at the recommendation of the fire underwriters. Our whole city is now on the fire engine stream basis, and we carry only 80 pounds.

John N. Chester: The hydrant connection then only becomes a matter of convenience to attach the size suction hose they have to your hydrant?

A. S. Holway: No, it comes down to a question of fire rates in the end. We have certain deficiency points to overcome and the underwriters put quite a heavy charge against small hydrants and it is just a question of dollars and cents. It pays. We have not replaced all the old hydrants with the $2\frac{1}{2}$-inch openings, but there is a great deal of friction on a $2\frac{1}{2}$-inch opening at a thousand gallons a minute; the friction at that point is too high to be carried, it does not pay.

John N. Chester: It will fill the pump.

A. S. Holway: Yes, but it carries the pressure too low, makes too much work for the pump.

J. G. Valentino: Did I understand Mr. Gibson and one or two of the other gentlemen to state that two $2\frac{1}{2}$-inch connections were just as satisfactory or you would get as much water from them as you would from a $4\frac{1}{2}$-inch?

Dow R. Gwinn: I do not see any difference. As a matter of fact, if there is sufficient pressure, they will get all they can take care of with their pumper with two $2\frac{1}{2}$-inch openings.

William W. Brush: Our standard low service hydrant has one $2\frac{1}{2}$-inch and one $4\frac{1}{2}$-inch outlet. The water pressure at the hydrant varies from a minimum of about 25 pounds to a maximum of over

100 pounds, the average pressure being approximately 40 to 45 pounds. No difficulty has been experienced by the New York Fire Department in using the larger size outlet. If the fire department of any community is equipped with fittings that increase from 2½-inch to 4½-inch and such fitting be placed on the 2½-inch outlet to the hydrant with a 4½-inch hose running to the fire ingine, the reduction in delivery from the hydrant with the 2½-inch outlet as compared with a 4½-inch outlet would be very slight, and practically negligible. We believe that the convenience to the firemen in connecting up their large suction hose to our 4½-inch hydrant outlet is of sufficient value to justify the use of this larger outlet, but if any community is equipped with 2½-inch outlets and wishes to deliver a larger quantity of water to the fire engine than will be furnished with a 2½-inch hose, such community can get practically the same delivery of water to the fire engine by using 4½-inch hose with a reducing coupling between the hose and the 2½-inch outlet as would be secured if a 4½-inch outlet to the hydrant were provided.

A MEMBER: Is it good from a waterworks standpoint to go to that extreme? Is it not the job of the pumper to take the water at a fair service pressure and deliver it at the fire pressure?

PRESIDENT CRAMER: As to expense, we who are under contract to furnish an agreed pressure have no choice in the matter, we are all hoping to get away from the responsibility of furnishing fire pressure and we hope the campaign started by Mr. Charles Henderson and so well championed by Mr. Jensen at the Canadian Section this week will bear fruit and that the day will soon come when we will furnish volume under normal pressure only.

ISAAC S. WALKER: I have been much interested in this discussion because, as it happens, the three different water companies with which I am associated, one in Pennsylvania and two in Indiana, have all been inspected and reported upon by the Fire Underwriters during the past year. The two Indiana reports, being for cities with a population of less than 25,000, were made by the Indiana State Inspection Bureau. The report on our Pennsylvania plant, being for a city greater than 25,000 population, was made by the National Board of Fire Underwriters. The National Board only deals with cities in excess of 25,000 population.

Whether made by the National or State Boards, however, all the reports on these cities were in the same general form. The recommendations covering hydrants were: "That all hydrants installed in the future have one $4\frac{1}{2}$-inch steamer connection and two $2\frac{1}{2}$-inch outlets; not less than 6-inch barrel, $5\frac{1}{4}$-inch valve opening, and 6-inch connection to main provided with a gate valve."

These are evidently general requirements by the Fire Underwriters for all cases, and it would appear that they did not give consideration to the pressure on the system in their specification for the size and outlets of hydrants. As to the particular point under discussion, there is no question that the usual $2\frac{1}{2}$-inch outlets will, at 75 pounds pressure, deliver all the water that would ever be required by a pumper. From one hydrant, in fact, if this pressure were maintained, one $2\frac{1}{2}$-inch outlet would be adequate when coupled to the fire pump suction.

The question stipulates 75 pounds as the pressure above which it may be unnecessary to provide steamer outlets. By inference, we might assume that it would be desirable to install steamer connections where pressures fall below 75 pounds. Now it is within the bounds of possibility that, even in the best operated plants, working under average pressure of 75 pounds or greater, that pressures in a district where a fire occurs may fall below 75 pounds and in case of excessive demand, or break or accident during the fire, the available pressure at the hydrant may be reduced to only a few pounds.

Under such conditions, the $4\frac{1}{2}$-inch outlet to the pump section would be practically indispensable, and this, I judge, is the reason for the more or less universal condemnation by the Fire Underwriters of installing hydrants without steamer outlets. It is simply a question of having a suitable size suction for the fire pump available under any low pressure conditions in the piping system.

City governors, furthermore, being interested in low insurance rates for their community, while they may be lax in following the Underwriter's recommendations, as applied to themselves, are usually pretty keen in requesting the water company to comply. It would seem to the speaker, therefore, that the wiser policy in this matter is to use hydrants with steamer outlets, in accordance with the Underwriter's recommendations. The additional cost is not excessive; it will satisfy the public, and, in the case of low pressure emergency, they are there for service.

W. C. Hawley: The question of insurance does not enter into this problem at all. The thing I have been afraid of is the blowing off of hydrants due to shock and jar of the engine. Our plant has been inspected by the County Board of Underwriters and passed as one of the best in the county. The Board has not requested the $4\frac{1}{2}$-inch nozzle, and the engineer of the Board has told me they do not want it.

Dow R. Gwinn: The point Mr. Hawley makes is that it is not a matter of insurance, but a practical question, that the pulsation of the pumper may blow off the hydrant. After I had some correspondence with Mr. Hawley, we had occasion to put in about 15 five-inch hydrants along a street where the sidewalk would probably be excavated, leaving the hydrants in the areaway, so I took the precaution of having a shackle put around between the main and the fire hydrant, about $1\frac{1}{4}$-inch round iron, so as to be on the safe side. We have not had much experience with pumpers yet. Some of the rest of you may be very sorry that they ever had pumpers put in, if they have large connections.

William Luscombe: After all it seems to me it resolves itself down to purely a question of local conditions, such as the pressures required to furnish satisfactory service, requirements of the Underwriters, also other factors that effect the case.

Stephen H. Taylor: In New Bedford we carry pressures up to 90 pounds and have $2\frac{1}{2}$ and $4\frac{1}{2}$-inch nozzles on all our hydrants. The pumpers almost always want the $4\frac{1}{2}$ and we have had no trouble from blowing out of hydrants. We back them up in trenches with heavy blocks and stones.

WHO PAYS COST OF METER REPAIRS WHEN DAMAGED BY HOT WATER?

JOHN N. CHESTER: I think a good clause in the water rules is that the consumer shall pay for all damage from external causes or extremes of temperature.

A MEMBER: On that clause there is one point I believe that is a little bit broad; if the meter is installed in a pit designed by the water company or municipality and the meter is set there on your order, why hang it onto the other fellow?

JOHN N. CHESTER: There is always an accompanying rule that the consumer shall furnish the housing for the meter.

WILLIAM LUSCOMBE: At Gary, Indiana, any repairs to the meter on account of damage by hot water or frost is charged to the consumer. Such meter repair bills are attached to the regular water bill. As has been stated, sometimes the consumer postpones paying for the meter repairs, but we make collections in all such cases without exception; in fact, in an extreme case of nonpayment we discontinue the service the same as for a delinquent water bill. However, we have been obliged to resort to that method in only a very few instances.

In order to prevent damage to the meter by hot water, we have used various socalled relief valves in connection with the ordinary check valve, but we have never found a satisfactory relief valve, that is, one that was absolutely dependable and positive in its action, and which we could recommend or be responsible for. The nearest thing I have seen approaching such a positive device in my estimation is what is called the "red top" relief valve, recently manufactured by a Philadelphia concern. It is claimed to be noncorrosive and rust proof and the only working part is a solid lead ball, the application of which is upon the dead weight principle. I should be interested to learn if anyone present has used that valve, and, if so, with what success.

We experience a great deal of trouble on account of damage to meters by hot water, and I should like to hear from anyone who has used check and relief valves or other means to overcome it successfully.

J. W. Toyne: We do not place a check valve to prevent hot water going in the meter, due to the hazard from the possibility of explosion. I will say though that we invariably collect for the damage done to the meter through hot water and through frost, when the meter is installed in the housing furnished by the consumer. However, if the meter is set in one of the pits that we put in to house it, we have not the nerve to collect on that.

Frank A. Marston: There is a valve known as the Stack valve which is made in the vicinity of Boston and perhaps is more of a local article. It is really a faucet which takes the place of the hot water faucet in the sink nearby, and as such is used frequently the same as any faucet in the house, and for that reason stands a much better chance of being in working condition when needed than valves put on top of the hot water tank which are not used except perhaps once a year, or more infrequently when the pressure goes up. As a property owner, I object seriously to putting a check valve on the service line. I prefer to take the chances of paying for damage to the meter in case the hot water goes back rather than to depend on an automatic valve.

John N. Chester: I have been connected with the operation of over fifty water works and have not heard this question of hot water destroying meters raised often enough to make it a hundredth part of one per cent. I think we are treading all around a small thing and taking a whole lot of time to do it.

GENERAL DISCUSSION ON SETTING METERS

Dow R. Gwinn: When the last big lot of meters were set in Terre Haute in 1915, a lot of repair business was done by the plumbers. We gave the consumers about a month's notice. One of the plumbers came in, a plumber who had been in business for a great many years, and he said that he had a customer in whose house he had done plumbing for eighteen years and during that time the consumer had a water closet that ran for eighteen years; he was positive because he had asked the man every time he went there, "Shall I fix up that water closet for you?" "Oh, no, that does not bother me any, let the water company pay for it; I have not got a meter." But the plumber said that the day we put the meter on this man called him three times, "Come down and fix that water closet, the water company has put a meter on." I do not know but that thirty days is sufficient notice.

John N. Chester: Do you not think you had better charge him the first month, and if there is any negotiation at all, let it be an adjustment of the bill? Let the charge start the day you get the meter on.

James E. Gibson: I think if you begin to compromise on the first bill, you will be continually troubled with compromises. Whatever a customer's excuse may be, it is a good one to him, though it may be a poor one to you.

G. E. Shoemaker: At Waterloo, Iowa, we started setting meters on all consumers in 1910. We wrote a letter to each consumer notifying them that on a certain day we would be there to set a meter, and, beginning from the date the meter would be set, water would be charged on a metered basis. We advised them to secure a plumber to repair leaks, so that all wastage of water would be stopped prior to setting the meter. We had no trouble of any kind by this method.

JAMES E. GIBSON: I want to add one point to what I have said, that is, when we put meters in in Charleston we had about 5500 consumers and were pumping around 7,000,000 gallons of water per day. Today with over 9000 consumers we are pumping approximately 5,500,000 gallons, an increase of 63 per cent in consumers with a reduction of over 20 per cent in the amount of water pumped.

JOHN N. CHESTER: I think they say 44 out of 48 states have utility commissions and with them we file our operating rules, and if they keep those rules filed they are law, and if we do not outline whom we have a right to meter we have fallen short in our filing; if we do, we have got that matter settled.

STEPHEN H. TAYLOR: In New Bedford our city solicitor ruled that while we could insist upon payment by meter measurement we could not force a consumer to buy the meter. We give him the option of either renting or buying.

J. M. DIVEN: We put the meters on as our leak detectors. Is it not fair to let the consumer have the benefit of the leak detector to point out the leaks to him, giving him opportunity to stop them before he is charged for the water they waste? 'Small leaks are not easily found and a plumber or other person going over a house might easily fail to detect a leaking water closet or other fixture. But the meter would tell that there was a leak and cause a more thorough examination. A water closet might be leaking several hundred gallons a day without the owner noticing it. When he gets notice that a meter is to be set he thinks that all is right with his plumbing and so he does nothing about having leaks stopped. Of course, you will say the water is wasted just the same and should be paid for, but is not the saving in friction and the satisfaction of the consumer worth more than the water wasted? When the meter has told a consumer that he is using an excess amount of water or is allowing it to run to waste he is not entitled to any sympathy or consideration if he does not try to correct the fault.

LEGAL DECISIONS ON RIGHT TO CHARGE MORE THAN ONE MINIMUM RATE OR SERVICE CHARGE ON MULTI-FAMILY HOUSES

JOHN N. CHESTER: I wish to commend to you in answer to your question the definition of the term "consumer" formulated by the New Jersey Commission and which has been adopted, I believe, as a standard by a great many other commissions.

It is as follows:

"Consumer" as used herein shall be the party receiving service for a property as hereinafter classified, i.e.,

a. A building under one roof owned by one party and occupied as one business or residence, or

b. A combination of buildings owned by one party in one common enclosure occupied by one family or business, or

c. The one side of a double house, having a solid vertical partition wall, or

d. One side or a part of a house occupied by one family, even though the closet and other fixtures be used in common.

We found in our practice, in order to meet all conditions arising, the necessity of adding to the above two stipulations as follows:

e. A building owned by one party of more than one apartment and using in common one hall and one entrance, or

f. A building owned by one party having a number of apartments or offices and using in common one hall and one or more means of entrance.

And as explanatory to the above we generally append the following:

Each consumer will be supplied through a separate meter, where service is by meter, except, however, in the case of (*d*), (*e*) and (*f*) as above defined, should the landlord or owner desire that the accounts of each consumer be kept separate he must first provide means of supplying, controlling the supply, and housing the metering device for each tenant, the controlling device to be outside the building and the measuring device or meter to be properly and conveniently housed either outside or within the building.

The Pennsylvania Commission has commended to utilities the above definition and you will note that, if you adopt the same, you will have the right to charge more than one minimum on a multi-family house.

As regards which option the landlord will elect it matters little, for, if he assumes the burden, he buys water by meter, pays one service charge or minimum and a much larger consumers' charge than otherwise, from the fact that the consumer pays by flat rate, or, if he makes it possible for you to deal with each family direct, you receive two minima or service charges and a smaller consumption charge and in the end the results are practically the same.

W. C. Hawley: In the case of the Vandergrift Water Company, Westmoreland County, Pennsylvania, the courts decided that a minimum rate might be charged for each occupancy or tenant. I believe the particular case was that of a building in which there were stores on the first floor and apartments above. That brings up a very nice question of management. Our rule provides that where a property can be divided and sold, we charge a minimum rate; we do not attempt to charge for separate apartments; we do not attempt to charge a multiple minimum for duplex houses because of the practical difficulties. For instance, we have one apartment house with some fifty odd apartments; now, if we did charge a minimum rate for each one of those apartments, every time a tenant moved out and the apartment is vacant a few weeks, there would be an adjustment of the minimum rate. We find as a practical matter that each apartment used on the average more than the amount allowed by the minimum rate, and we charge therefore one minimum and collect at stated periods for the water used.

Dow R. Gwinn: That is the plan we work on.

John N. Chester: We had a case, during the war, at Edgeworth, Pennsylvania. We had a house shortage and our consumption was increasing and our revenue was decreasing disproportionately to our operating expenses, and we cast about for how to get more revenue. It occurred to us that probably one third of all the houses in that district had rented out rooms during the war, on account of the house shortage, and fully another third had taken in a second family, and we wrote the Public Service Commission asking them for permission to inflict double minima where there were two families occupying a house and compel the families to divide the consumption charge, and, if they refused to do it, to shut the water off from the whole building and not turn it on until both bills were paid,

holding the landlord for it. In the emergency, they allowed us to do that, but that was a war emergency and we still hold the rule and charge them two minima and the consumption charge is divided between the families.

A. S. Holway: We are on a service charge basis; we charge one service charge on each meter, we do not care whether there is one person consuming from that meter or a thousand; I think that is the fairest way.

Isaac S. Walker: We have one case which is a little aside from the question, but may be of interest. In one of our towns there is a large industrial concern, which has a community village of about 125 houses, for the use of their employees. Being a private enterprise on their own property, they installed their own street mains for water supply.

It is the practice of this concern to furnish their employees with free water, and when they applied for water service, several years ago, the question arose as to how to charge for this strictly domestic service, under a set of rules which prescribe that each house be considered as an independent service. The owners of the concern would not install separate meters in each house, as they furnished water free, and were not interested in the amount used in each house. We would not install the meters as it was a private enterprise. The question was settled in what seemed to be the most satisfactory way by locating a single large meter on their supply main and taking the total registration as the basis of billing. The bill could not be computed in the regular way, as the combined consumption would run into the lower sliding rates of the schedule, thus giving the owners the benefit of industrial rates for small dwellings. So the total registration is decided by the total number of houses connected, to ascertain the average amount used in each house, and the unit bill is computed on the basis of this consumption. If this average amount is below the minimum allowance of 3333 gallons, each unit bill is considered to be a minimum bill, and the total bill for the 125 houses is rendered on this basis, i.e., 125 times the unit minimum bill. This method reduces the billing to the equivalent of individual metered service, and was accepted without question by the property owners.

W. S. PATTON: Take a business house; they put in one meter and probably one store will occupy the whole building. Later on, maybe the building will be divided up and there will be three or four stores on the first floor and two or three factories on the other floors. The original meter worked all right in the beginning, but now each of those tenants wants a separate meter. What is the general custom with other superintendents? As many meters as they want in the basement, or to supply the water to the landlord and require him to be responsible for all the bills and let him supply his own meters and bill his own consumers? It is a problem with us. It seems to us that the water works ought to endeavor to supply the need as far as it can; in other words, give the consumer whatever he wants, but charge enough to make it pay. I should like to know what other people are doing.

JOHN N. CHESTER: Give the owner of the building his choice; let him divide up his plumbing so that you can deal with each consumer or let him pay the whole bill.

W. S. PATTON: Would the water works supply all those meters at its own expense?

JOHN N. CHESTER: If they built a row of houses, would you not be glad to supply meters for them?

W. S. PATTON: Here is the proposition, you open a lot of new accounts and in a little while some of those meters will be taken out. It means taking meters out and putting them in. I do not see any disadvantage in that, the only thing is the extra expense.

JOHN N. CHESTER: Do you not have a place for those meters when you take them out?

W. S. PATTON: We placed all our meters at the curb. We have one line going into the building; this other way, the landlord would have to put service lines down to the basement and the other meters would be placed in the basement. I want to find out whether that is the custom with the other plants. We make no charge whatever for installing the meters.

JAMES E. GIBSON: Charleston is peculiar in this regard because in anti-bellum times the slaves lived in tenements in the rear of the main house. In more recent years those tenements have been remodeled and rented out as tenant houses. When we took over the water company we adopted a rule that we would grant only one service to each premise unless conditions required more than one service to supply adequately the property. The question at once arose as to what constituted a premise, and, after considerable thought, a premise was defined by our board as a property that can be entered from the street without invading the privacy of any other person, or in the case of apartments or twin houses an entrance wherein a person might take refuge from storm without invading the privacy of any of the tenants of the property in question. Under this definition we will grant services to each of the apartments. In addition to this we have to take care of the tenant houses in the rear, mentioned above, in which case we add an additional minimum to the service charge for the rear house. This service charge is based upon the size of the apartments in the rear, that is, the number of rooms. If the owner desires it, and will grant the permission, we will lay additional services for each of these tenant houses, in which case we charge the full minimum the same as if the property faced the street. It goes without saying that these additional services are furnished with meters. It would seem, therefore, that we had eliminated trouble, but far from it.

A party will build a twin apartment and comply with our requirements as to separate entrances and privacy of entrance, but then comes the plumber and he is only out for the money; not caring anything about how the water is supplied so long as he makes connections and gets the water to the premise. The result is that Mr. A, who lives in the second story apartment, desires a water closet for his servant and makes a contract with his plumber to install this closet. Those of you who are not familiar with conditions in the South must understand that these closets are always installed in small buildings in the yard as the people will not permit the servants, (negroes, as a rule), to use the fixtures of the main house. The plumber, without rhyme or reason, connects the water supply of this toilet, in a good many instances, to Mr. B's supply which is the downstairs apartment. Things go along nicely until this closet (usually of the cheap variety) breaks loose and runs up a high water bill. Mr. A knows nothing of this as he never inspects

the servant's toilet, but when Mr. B receives the high water bill he "goes up in the air" and after investigation finds that the cause of this high water bill is Mr. A's servant's toilet, but the water department insists upon Mr. B paying the bill, and, of course, we get the blame. In most of the instances we have been able to act as peace-maker between Mr. A and Mr. B, and get the matter finally adjusted without getting our fingers burnt, but it is not always so rosy.

However, we refuse to set more than one meter to a premise and do not permit submetering. Occasionally, the owner is desirous of metering each tenant in his houses so he will undertake this submetering himself in which case we sell him the meters at actual cost to us plus a small fee for storage and interest. However, we have nothing to do with the reading and billing on these meters. I can recall two or three cases, but usually after a few months they come back and ask us if we will not take the meters off their hands as they find it too much trouble and would rather pay the full minimum themselves, and charge the tenants a sufficient sum to cover the water in the rent for the apartments.

We had one other difficulty to contend with and that was that of the split service; that is, one tap would be made on the main and a service pipe run to the sidewalk and then split into several services. We have had to abandon this as we found it unsatisfactory.

Dow R. Gwinn: Mr. Gibson is right; I do not know anything in the water works business that is rosy unless it is drawing your pay.

W. C. Hawley: I think this question of more than one meter in a property usually solves itself, at least in the north, by the fact that the plumber, when he installs the plumbing, does not install it for each separate apartment or each separate store. He has one hot water system for the whole building and you cannot put a meter in that will meter the separate apartments. When the landlord comes in and wants to do that, all you have to do is to say, "Fix your plumbing so it can be done." He goes back and interviews the plumber and decides that he will go along just as it is.

J. W. McEvoy: It seems to me there are two ways to look at this; one, the municipal plant, bought, paid for and owned by the people who are entitled to the very lowest possible rates and the best

accommodations; the other, the privately owned plant, paid for by a privately owned company or corporation who have no way of getting any revenue other than from the consumption. In that case there is not any question but that they must cut every corner and increase their revenue as much as possible to make an earning, to make a profit and take care of depreciation. Now, in a municipally owned plant, it seems to me it is only fair to the property owner who has paid for that plant in a tax, to have the privilege, if he so chooses, to put in one meter to serve as many tenants as he sees fits. In Dubuque we allow the owner to serve as many tenants as he sees fit through one meter.

EXPERIENCE WITH FLUSHOMETER WATER CLOSETS

Dow R. Gwinn: This is a live question, as very large services are being demanded for such closets and the large flows required may involve water hammer trouble. Water works authorities should regulate their use before they are in too general use. I shall say in the beginning of this question that we had a plumber come into the office about a year ago and he said, "I put in a flushometer closet and I want a $1\frac{1}{4}$-inch line." "How large a house is it?" "Five room house; he has one of those flushometer closets." I said, "We cannot supply a $1\frac{1}{4}$-inch line; if we supplied him with a $1\frac{1}{4}$-inch line, everybody else might want one. We will run a $\frac{5}{8}$-inch line to the curb, and $1\frac{1}{4}$-inch can be laid from that point." A 40-gallon range boiler was installed in the basement and the $1\frac{1}{4}$-inch line connected at the bottom, the supply for the water closet was taken out near the bottom with a pet cock at the top and at the bottom. It gathered considerable air and furnished a cushion, and the air pressure gave a very satisfactory flush. Every now and then it would be necessary to drain this tank and fill it with air again. It is a good deal better for us than putting a $1\frac{1}{4}$-inch line from the main where a $\frac{5}{8}$-inch will answer.

John N. Chester: I did not intend to say anything on this question this morning, but since I expressed views contrary to what you quoted for me, I must at least harmonize them. First, I like your plan, if you are intent on keeping down the size of your service, but Mr. Gwinn quotes me, I think, from a discussion wherein it was a question whether they should have the whole system piped into a place, or a reasonable proportion of it. I do not regard a $1\frac{1}{4}$-inch pipe, with a meter between the user and the main as detrimental, except on single lines of 4-inch pipe, for I believe that we might gain considerable revenue by permitting the $1\frac{1}{4}$-inch connection or service if we have a heavy service charge graduated according to size of service and meter, that is, it steps up with every increased size, and if you have a \$6.00 service charge for a $\frac{5}{8}$- or $\frac{1}{2}$-inch pipe, it ought to be at least \$1.00 more for 1-inch and \$1.50 more for a $1\frac{1}{4}$-inch pipe per month. That type of minimum has solved the question for us. There are

very few people who want flushometer closets when they find that they must pay an additional service charge or minimum in order to get them and if your service charge does not provide for it, if you have not a graduated charge, let me urge that that graduation is the easiest way of regulating the flushometer closet. When you get into a community such as one of our clients who is supplying the village of Edgeworth, where the houses are all large and the population is constituted of that class of people who want what they want when they want it, regardless of cost, if they are willing to pay for it, let them have it. We do not discourage a man at all if he comes in and applies for a 2-inch pipe. We only wish to be reasonably certain that he is going to continue to use that 2-inch pipe if it is put in; so he gets a 2-inch pipe if he wants it, or if he wants a 1¼-inch pipe he gets it, but he is given to understand that his minimum will be so much and he is going to be held a certain number of years for that minimum if he is the property owner; if he is not, he cannot get the service. That policy has increased the revenue and has not impaired the service.

W. S. Cramer: What size meter do you use?

John N. Chester: Generally we put a 1¼-inch on a 1¼-inch line.

W. S. Cramer: We found in many cases that the trouble was overcome by running a 1¼-inch pipe and in almost all cases it was on the short side of the street. The $1.50 minimum a month did not stop the use of flushometers, but a three dollar minimum did.

W. C. Hawley: This flushometer proposition came up with us some years ago, and I immediately took the position that while we were willing to furnish all the water that the consumer wanted and we were glad if he took a lot of it, we were not willing to furnish 99 per cent of the water in 1 per cent of the time. By the use of a tank such as Mr. Gwinn has suggested, or a piece of 8-inch pipe, 6 feet long, or an air tank, we have solved the problem. We are furnishing in one case, a schoolhouse with 20 flushometer closets and a one inch service line, with an air tank, and they get satisfactory service.

Chester R. McFarland: One or two questions arise in this matter that are interesting. The first question is, what is the effect

on the meter of the use of flushometer closets? Does it not destroy the meter in a short time, the opening and closing of those flushometers? That is one of the questions with which I am not familiar, and I am asking for information. Now there is another side of this that probably has not been thought of; you take a number of those large services, $1\frac{1}{4}$-inch and $1\frac{1}{2}$-inch to supply these flushometers and let a fire break out in that district and, the first, thing you know, fifteen or twenty houses having these large openings in them burn down and what is the result? If that district is made up with 6-inch mains, what is the result of the pressure you can maintain on your system with all these flushometer pipes open and running when the fire is going on? It seems to me that that is a very serious side of this question. That is the reason I am limiting, as I always have done, the size of connections for sprinkler systems. Now if we are going to step off in another direction and do the same thing, it seems to me we are likely to have bad results in case of any large fire. These are questions that have arisen in my own mind. Some of you gentlemen might be able to enlighten me as to the effects under those conditions.

JOHN N. CHESTER: In our case, if a conflagration like that is going on in the residence district and our superintendent did not have a man down there with a wrench to shut off those houses, there would be a new superintendent in that plant next day.

CHESTER R. MCFARLAND: That all sounds good, but practice is another thing.

JOHN N. CHESTER: The next thing is the demand made by several against the demand of one; there is only one-sixth the chance of that curb cock being covered up by the building falling down as against the one chance in the factory, assuming there are six houses burning. Of course, the large connection in the factory would not be so detrimental, if it were not for the breaking off and the impossibility of getting at the shut-off when the break occurs, but you have reduced that to a minimum by the number of services in question.

I may be educated up to this by this very district where the wealthy people of Pittsburgh have built homes with bath rooms numbering from three to ten in a house; leave out the flushometer, say they are equipped with a common closet, and what kind of service are you

going to give them with five, eight or ten bath rooms? That system has a lot of 4-inch pipe in it and that company is going to have water enough to keep its mains going as long as the revenue from the investment is commensurate with the investment. We have not felt any inconvenience from those large services in the Edgeworth District, which however is not a large district. It has only a 12-inch main coming from the reservoir and there are other districts beyond that to take water through the same 12-inch main, a large percentage of the pipe laid in that district is 4-inch; it was laid before I had anything to do with the plant. There has been nothing but 6-inch laid since, but we are not suffering the way you people think you are going to suffer. They do not all draw at once; if they all took a notion to flush their closets at once, there would be a diminution of pressure and they would wait, but that does not happen, those complaints have not come in and we are getting the greater revenue from the larger services.

A. S. Holway: We have had the same experience Mr. Chester has had. That was one of the principal reasons we changed from a minimum charge system to a service charge system. We believe the customer is entitled to whatever he wants and is willing to pay for, and we have no difficulty whatever from flushometer service.

C. W. Schiedel: How large a service is required if there is one flushometer in the house?

Dow R. Gwinn: Five-eighths inch. I want to give a consumer as large a pipe as necessary, but if a $\frac{5}{8}$-inch service will take care of the service including flushometer, why should I go to the expense of putting a $1\frac{1}{4}$-inch pipe from the main up to the curb at our expense? Why should we have the extra large pipes if $\frac{5}{8}$-inch will answer the purpose, and we have demonstrated that it does work all right? In several large buildings recently they wanted to put in flushometer closets, and we discouraged them as much as we could. I am speaking of a large business house, five or six stories high, where they were putting in a 2-inch line, but they put a tank on the roof with a return pipe coming down to the flushometer closets. When a prospective consumer comes in and talks about the flushometer closet, I tell him the experience I had at the Bellevue Stratford where the closet was not supplied with sufficient water to get a satisfactory flush. I went

to the Claypool at Indianapolis and they had put in such a good one that the water was thrown out on the floor. This is something of a fad that is going to run out after a while. In the meantime, if they want to have that kind of fixture they can put a range boiler in the basement.

WILLIAM W. BRUSH: With your tank or boiler in the cellar, as I understood, you had to replenish the air about every three or four months.

DOW R. GWINN: I do not think it is oftener than that.

WILLIAM W. BRUSH: Have you ever tested how much air is left in the tank?

DOW R. GWINN: No.

WILLIAM W. BRUSH: Did you ever try to by-pass your tank?

DOW R. GWINN: No. As long as the man and his wife were satisfied, we did not bother.

HENRY P. BOHMANN: What is the minimum pressure?

DOW R. GWINN: We have about 45 pounds in the residence district.

J. M. DIVEN: In allowing large direct services for flushometer closets, are we not doing very much the same thing we would be doing in supplying locomotive cranes direct, without the use of a tank? I do not think many of us would sanction a direct connection for a locomotive crane, as they use very large outlets, 8- or 10-inch, in order to be able to fill the locomotive tank quickly. A direct connection for this purpose would be apt to cause very serious water hammer, and would not the same be likely to occur if we allowed the services as large as are requested for flushometer closets. A hotel or apartment house would need about as large a supply pipe for this use as the railroad would for their crane if directly connected, and there is no telling how many closets might be used at the same time, all shut off suddenly, causing considerable water hammer.

J. W. Toyne: With the flush valve installation we have, we have found in almost every case that a $\frac{3}{4}$-inch service is large enough from the street to the property line, with $1\frac{1}{4}$-inch piping inside.

J. Walter Ackerman: Relative to the question of the expansion tank, in connection with the use of the flushometer, some years ago I put in an ordinary 40-gallon heating tank, as an expansion tank, in order to provide a cushion for the registration of a recording gauge to dampen out the water hammer due to some water elevators near by. It was fitted up so that, with a glass gauge near the top, one could tell where your air line was. It was fixed so you could by-pass around it and empty it when it was absorbed. Now my experience was that a 40-gallon tank would absorb all the air I could get in there, inside of twenty-four hours. I thought when I was building the thing that that would be a very fine arrangement but I did put the glass in so I would know exactly where my water line came. Inside of twenty-four hours I had no air left in the tank.

J. W. Toyne: I have a tank that carries just the atmosphere air for over two months.

LOCATION RECORDS OF WATER SERVICES

James E. Gibson: We inherited a complicated condition. The private water company had no definite or systematic policy. When the Goose Creek supply was first introduced they had a surplus of water and a deficit of consumers. In order to obtain consumers they would lay service pipes under almost any condition, across lots, into the rear of houses, and if they did not happen to have a main on the street on which the prospective consumer lived, they would go to the next street or even as far as two streets away and lay a small service pipe to obtain a consumer.

The city purchased the plant in 1917, since which date we have laid mains in all the streets in the older portion of the city and have done away with these small services. We insist that each service enter the premise from the front on the street on which the house takes the number.

We make no attempt to keep a record of the exact location of the service other than that of the meter box. The meter box is set at the curb and the service pipe is laid at right angles direct to the main. A record of the size of the service, number of feet and material used, together with the size of the main and nature of street paving is made on 3 by 5 cards and filed in a card index cabinet according to street and location. No record other than house number and street is kept and if the owner desires to know anything about his service he gives us his house number and street and by referring to the card index system we can give him the complete record of his service. Our object in filing according to house number and street is obvious, in that we do not have to keep changing our records for property changes.

James Woolley: I might say that in the City of Newark, N. J., when we put a line through a street, we always put the service to the curb, but, before doing that, we notify the property owner that we are about to put a main through the street and he is supposed to designate whether he wants a service every 25 or 50 feet, whichever it may be. We put the service in to the curb and we maintain it so

that when he is ready to build, all he has to do is to make application. We do not allow people to come along afterwards and rip up the street to get a service. A newly paved street cannot be opened up in less than five years; they must notify us when the service is put in.

FRED D. MANVILLE: In Newport News we put them in the center of the house, if there is a house on the lot. If there is no house we do not put in a service.

WILLIAM W. BRUSH: In New York City we require that the service shall be laid from the main to the building on a line at right angles to the main or to the street line, where the tap is located, the nearest intersecting street curb line. That informatin, together with other data, is placed on the card, so that every tap has a card. Unfortunately that has not always been done in the past and we have a good many thousands of services where we have not such a record, but, for many years past, such a record has been kept. I believe that those who have to put in services would find it worth their while to make an accurate record of the service, which will very possibly not be used for the next twenty years, but thirty years from now it will be very useful to know just where the tap is in the main.

(No curb box is used in New York City—*Editor*.)

W. S. CRAMER: About four years ago immediately after quite a large fire in Lexington, I was very glad we did have street measurements. We had one, two, three or four $\frac{5}{8}$-inch services all buried under 5 to 15 feet of hot brick, and were able to get to them in the course of two hours.

DOW R. GWINN: I think it is important to have a record of every service. When I went to Terre Haute, we had to call in, first one man, and then another, to ask him where the main was located and get what information we could, but what I was afraid of was that these men might die in the course of one hundred and fifty years and there would be nobody to give us the information.

Every application that comes in has a number which never changes, and we have an envelope, about $4\frac{1}{2}$ by 9 inches, and each envelope has a number corresponding with the application number. On the outside of the envelope is a printed form for the location of the corporation cock, distance from the property line and from the nearest

street at right angles, and also the location of the service box and the size of the service. Then inside the envelope we put the report of the foreman who made the tap, the men who worked on the tap, the location of the main in the street, the size of the main and the depth below the surface. With that information we were able to make out a street record which was fairly complete. Now when a man comes in and wants to know about a service, all he needs to do is to give us the number of the street and we can turn to that application number and give the information he wants.

W. S. Cramer: In helping to rebuild one of those old southern towns, I should like to tell you that I took the property line just as you have done originally. I had to go back and change it and go back to the original property line of the street and measure from the street intersection rather than the original property lines. Your property lines are changed so that they would be of no use whatever.

James E. Gibson: In connection with old services, we use the electric pipe locater. In a number of cases we have found two or more services entering the same property. In a few cases we had metered one of these services and only discovered the other by accident or when someone got into trouble. Our experience with the pipe locator has been very satisfactory. We have located service pipes 2 to 3 feet under ground, when there were no records in the office or no memory of any such service having ever been laid.

THE USE OF POWER OR GASOLINE PUMPS FOR TRENCH WORK

William W. Brush: The gasoline pump is part of our regular yard equipment. Each repair company has one or more diaphragm pumps driven by gasoline engines. I saw in Philadelphia what impressed me as being a mighty good scheme. There they have taken a Ford chassis from a car that has served its time and was to go to the scrap heap, stripped it and then mounted a gasoline diaphragm pump on this chassis with a light steel frame, a canvas cover and a tool box. This outfit is used as a trailer, taken on the job and can readily be moved by hand. I was told that old pneumatic tires were put on the wheels so that this pumping outfit could be left out without any attendant over night. They are more honest in Philadelphia than in New York, because I do not think there would be any pump, tire, chassis or anything else left in the morning, if we left such an outfit out on the street.

LAYING WATER MAINS OR SERVICES IN TRENCHES WITH SEWER PIPE

William W. Brush: In New York, we lay the water main in the sewer trench, and the service pipe is laid in the sewer trench to the house. Rock is difficult and expensive to remove. The laying of the pipe in the sewer trench has not caused us any particular trouble. We have more trouble with our rock filled streets than we do with our streets where the pipe is laid in the sewer trench, and by using the sewer trench it has reduced materially the cost of installation to the city and of the service to the community. Where rock is at the subgrade of a street, the cost of removing that rock is a large item. While there are some obvious disadvantages in this practice, we believe that the advantages outweigh the disadvantages. The practice is one that we expect to continue.

Our main has a 4-foot cover, and I should judge that the sewer must be about twice as deep. The water mains are laid on the back filling of the sewer trench. I should state that we do not lay the water pipe at the same time the sewers are being laid. The water pipe is usually laid several months or several years after the sewer has been installed and, therefore, after the ground has had a chance to settle.

Warner C. Brockway: I should like to ask if that is for general construction or is it just where you have rock excavation?

William W. Brush: It is only where we have rock excavation. We have definite distances which vary in each borough as to the distance from the curb to the water main. We have considered making the distance uniform, but we found that that would not be helpful because all other subsurface structures are laid out in relation to the water main, and the result is that each borough has its own regulations as to the distance to the curb for the various subsurface structures, the telephone ducts and the electric light ducts and sewers all have their particular location, and we do not attempt to make uniform the distance from the curb to the water main in the

different boroughs. That distance varies from six to nine feet from the curb, and it is only when we have rock that is virtually to subgrade of the street that we put the main in the sewer trench; otherwise, it is laid at the usual distance from the curb.

WARNER C. BROCKWAY: Is your topography such that your sewer line does not conflict with the water line?

WILLIAM W. BRUSH: The sewer line is always below the water line, so it does not interfere in any way, and at the manholes our sewer trench is wide enough so that we can lay by the manholes as a rule without deflecting the line of the pipe.

A. V. RUGGLES: On the subject of practice as to laying water mains in sewer trenches, the rule in the Cleveland Water Department, also followed by our orders in all suburbs which we supply with water, is to lay water mains and sewers in separate trenches in the street in all cases. House connections for sewer and water are laid not closer together than 5-feet center to center, except in rock excavation. In the case of rock excavation we permit a ledge not less than 8 inches wide to be cut horizontally in the side of the sewer trench and on this ledge the water connection is laid. This brings the water connection not less than $1\frac{1}{2}$ feet higher than the sewer connection.

THE WATER WORKS COAL PILE[1]

J. W. Toyne: There are two points that the speaker brought out that attracted my attention. One thing was how essential it was to have an intelligent boiler room crew. I believe ours is barely good enough. If there is any scheme for securing that, I believe it would be of interest to everybody. Another thing, along towards the end of the paper he made a comparison between a municipally owned and a privately owned plant. I should not attempt either to deny or to clarify that except in one instance. I can point to a municipally owned plant that is operating largely on Indiana screenings, and that is operated slightly below the half ton.

W. S. Cramer: The Milwaukee plant is municipally owned. That is the best we have on record.

Dow R. Gwinn: I think we are under obligation to Mr. Maxwell for the tables he has prepared. I am sure they will be read and studied with interest by the members. I happen to know of another municipal plant run on the private ownership plan in Iowa.

W. S. Cramer: I want to say if you have never tried the bonus system to cut your coal cost down, try it and see how it works. I have been doing that for a few years now, and we have been getting some very good returns for it.

Henry P. Bohmann: Do not forget Milwaukee next year. We are putting in mechanical stokers and other new improvements which will be used by men who have been accustomed to hand firing for thirty or forty years.

Charles S. Denman: Since Mr. Maxwell obtained his figures we have installed at Des Moines a coal crusher. We grind our coal to a uniform size and estimate that this saves us about 5 per cent. The finer we prepare the coal, the better combustion obtained. The amount of combustible material in the ash is also reduced. When large pieces of coal enter the grates, holes in the fire develop which allow more air to enter than the gases will consume.

[1] Discussion of paper by this same title, by D. H. Maxwell, Journal, November, 1923, page 1072.

GEORGE W. FULLER: I do not carry those figures very well in my mind. There has been lots of practical information obtained, and I believe it is something that is well worthy of record. Varying temperatures and varying conditions of water call for different treatment. Different kinds of organisms call for different treatment. I believe copper sulphate has a distinct field of usefulness and can be used to great advantage. It would be a good idea to get out a questionnaire and summarize the latest information.

W. S. CRAMER: The use of copper sulphate, like a lot of other things, is so cheap and it is so hard to handle without getting more than the prescribed dose in, that it is pretty hard to handle it under one part in four million, and we try to get it down as low as a part in four million or a part in two million. It is awfully hard, even with a fast motor boat, to get your distribution over the entire surface when using very small quantities.

GEORGE W. FULLER: As I have visited works where growths are very objectionable as to tastes and odors, I find there is quite a difference in the way in which water departments function when there is need of using copper sulphate. In some places they always keep on hand an adequate amount of copper sulphate, and there is always some person delegated with authority to apply that copper sulphate quickly. There are other instances where copper sulphate has been needed very badly indeed, but they have not done so. There also seems to be a marked absence of adequate authority in some places for some one person to go ahead when conditions call for prompt action. These are two striking lapses I have run across in securing the benefit of copper sulphate.

W. S. CRAMER: If the man in charge of your filter plant has direct charge of that chemical, the same as the others, the filters will soon tell him when it is necessary to use it. There is one thing those who are interested in the copper sulphate treatment should take up, if

you have not already taken it up, and that is to watch the shallow nooks and small pools that are found and will flush after a rain, and dose them at least two or three times in between the times of your regular doses, and keep that growth down. That is where your growth comes from, you may kill the growth in the main body, but those nooks are incubators, and they are continually starting a growth in the main body. We have two spring branches that come into our reservoir, and I have a small paddle wheel and there is a sack on that paddle wheel, a very closely woven sack, and we fill that sack three times a week and it about exhausts the amount we put in there in two days. That takes care of the pools formed by these spring branches coming in where they connect with the main reservoir, and it keeps those pools very sightly. Before we adopted that treatment, they were continually covered with a green scum. They are along the main driveway and very close to the entrance to our main pumping station, and that treatment has kept them down very nicely. You want to watch all the main breeding spots and dose them much more heavily than the main body so that they will not propagate and come over into the main body.

WILLIAM H. LOVEJOY: Our chief difficulty at Louisville has been the shortening of the filter runs due to presence of microörganisms of different types, principally the diatoms Melosira and Synedra. During the past fifteen years we have experimented in the dosing of the water in our settling basins with copper sulphate, using varying doses of copper and different methods of applying it, in order to find the best method of killing the growth.

No amount of copper sulphate or method of dosing has ever proven entirely satisfactory to us in bringing the filter runs up to a normal length. We formerly used weekly doses of about one part per million of copper, but we are now using two or three doses weekly at a strength of one-half part per million and find that this smaller and more frequent dose gives better results on the filter runs than the larger dose.

The smaller dose of copper also has the advantage of causing less aftergrowth of bacteria in the filters and clear well. There are times, however, when neither a large nor a small dose of copper seems to do any good. This is probably due to either some peculiar combination of organisms being present or to unusually large amounts of amorphous matter. At such times our filters often run as short as

one or two hours. Such short runs obviously cause great operating difficulties.

Our algae growth is really a river growth and not a reservoir growth. For this reason it has to be treated differently than is the case with a purely reservoir growth. With a reservoir growth, the reservoir may be cut out of service, treated with copper, allowed to stand until the organisms have disappeared and then the water may be run onto the filters with safety. In our case, however, fresh organisms are being constantly added with the daily pumpage, making it necessary to treat the water continuously or at very frequent intervals. In the seventy-two-hour settling period in the reservoirs the count of organisms seldom increases more than 5 or 10 per cent above the river content.

Previously we used to treat one reservoir at a time and cut it out of service for two or three days, but we found that this method did not give good results. At present, we are using the method of treating both basins at the same time, adding half a part of copper at the inlet of each basin over a period of eighteen to twenty hours. Diffusion is very rapid in the case of copper sulphate, and we find that this method is much easier than that of dragging it in sacks from a boat and also the distribution is just as good as in the latter method.

Our settling reservoirs hold about three days' supply, one hundred million gallons against thirty-five million gallons daily consumption.

James E. Gibson: Our impounding reservoir holds something like three billion gallons of water. The average depth is about eight and one half feet, and the total area flood is a little over three square miles. With our warm climate the conditions for algae growth are ideal. When Mr. Bunker was at Charleston in charge of the City Laboratory he made a catalogue of the algae in our impounding reservoir, and, as I recall it, this catalogue was a list about 2 yards long. We do not attempt to identify the various growths as they all look alike to us when it comes to treatment. We use about 100 pounds of copper sulphate per day from the first of May until the middle of October, and use three methods of application: first, trail it from the stern of a boat in the large reservoir; second, we suspend in our intake a small amount in a gunny sack, with a cotton rope, that is allowed to dip to the surface of the water; the capillarity of this rope brings sufficient water to the copper sulphate to dissolve it so that there is a constant dripping of the solution into the supply

going to our low service pump; third, by the same method we introduce small amounts in our sedimentation basins which are two in number, the water passing through them in tandem. The copper sulphate solution is placed at the entrance of the water in each of the basins.

Occasionally, to stop the growth of algae in our clear water basin, we introduce in the main effluent from the filters a small amount of copper sulphate which we feel effectually stops the growth of algae in this basin. Our worst condition is in the fall of the year when the weather turns cool and the algae begin to die; the most aggravated period is when the water in the impounding reservoir turns over.

E. T. Cranch: At Petersburg, Virginia, we obtain our water from the Appomattox River, and have practically no algae to start with, but we have a three million gallon equalizing reservoir to which the filtered water is pumped and exposed to the hot sun. Here the algae develop rapidly. In previous years, every summer there was considerable complaint made about the taste of the water. Two years ago I started treating this reservoir with about three-tenths parts per million of copper sulphate. At this time we had no equipment for making a microscopic examination of the water. We received no complaints regarding the taste of the water until late in August, when some trouble did develop. Last year I started making microscopic examinations of the water and found that on the day after treating the reservoir with three-tenths parts per million of copper sulphate we still had an active algae growth. I then raised the dose to six-tenths parts per million and found that this eliminated practically all the algae, as I had no active growth after this treatment. I found that it took about two weeks for the algae to develop to any extent, so that I adopted the practice of treating this three million gallon reservoir every two weeks with 15 pounds of copper sulphate. We apply the copper sulphate by simply placing it in a burlap bag and dragging it from side to side of the reservoir. Since adopting this method of treatment we have had no further complaints regarding the taste of the water.

Fred D. Manville: In Newport News, we treat water, when it is needed, for crenothrix, and sometimes anabaena. This is determined by close observation of the water. We have used copper sulphate at the rate of two pounds per million gallons, but since the last

convention we have discovered that pretreatment with liquid chlorine seems to do away with the need of treatment with copper sulphate. That is, the water is treated with liquid chlorine and alum into the suction of the low lift pumps, then it goes over the aeration system into the coagulating basin. We are now using pretreatment with liquid chlorine in all of our water, as we find it does the work better, with better coagulation, and the amount of alum required is materially reduced. It is our intention to continue to treat the water this way the entire year.

We have used this pretreatment as high as 8 pounds per million gallons of water which was in bad condition, and after filtration we used 4 pounds per million.

Francis D. H. Lawlor: From what Mr. Lovejoy has said, I think his conditions must be very similar on the Ohio to the condition which Mr. Henderson has at Davenport, on the Mississippi. The intake comes into his plant from the river, and as I understand it, the settling basin has a capacity of about five million gallons, and instead of treating it with copper sulphate, he uses liquid chlorine, and his dose of liquid chlorine, if I remember his figures, is between 18 and 20 pounds per million gallons. He applies it in the fore bay and then this water goes through pressure filters, and they claim at Davenport that they get no taste or odor from the liquid chlorine with that 18 or 20 pounds per million gallons.

At our plant at Burlington, we never observed algae in the water until perhaps three or four years ago, and perhaps our troubles are not as serious as those at Davenport, but we simply get clear of the algae by more frequent washing of the filters; perhaps we double, roughly speaking, our percentage of wash water and wash it out, but we have gravity filters and are able to do that. Not having observed the water until a few years ago, I formed a theory that perhaps the algae were coming to us from the new drainage districts. The water stands in the old sloughs or swamps behind the levees and at certain times is pumped into the river. I had a theory that the algae were coming from these places. I do not know whether it is true or not; I have not been able to confirm it. If any of the gentlemen are interested, if they get in touch with Mr. Henderson, he will be able to give them further information.

ALEX MILNE: I had a little experience a number of years ago with algae growths. Our reservoir at St. Catharine's, Ontario, has three sections comprising a storage of 364 million gallons. At that time it was taking care of a storm water outflow of about twelve thousand acres. The upper section of the impounding reservoir had become almost filled up in the wash from the storm water in that area, a convenient spot for algae growths. Before having time to study the matter, we treated it in a crude way with copper sulphate for a couple years without very much result. On my recommendation the Board authorized me to clean out the upper impounding basin. We reduced the area about one-half, created a depth of 10 feet of water at the foot of the slope wall, cut out all possible chance for growths in that section, and then at the intake created a fan tail aerator and aerated all the water coming in, and that being too small for our consumption during peak period, we installed a 24-inch main at the lower end of the reservoir and put in a jet atomizer for the additional supply when required. The difference was immediately noticed. On examination of the water we found that we were liberating, destroying or letting loose a great deal of algae. If you stood on the windward side of the jet, you would think from the odor it was all let loose; we reduced the content by 65 per cent. We did not reduce it entirely, however, until the following year by a diverting canal diverting all the storm water from the reservoir, and then we got rid of all our algae. In the remarks of one of the speakers, it struck me as rather peculiar that he was destroying his algae by the use of chlorine. I did not find it very efficacious. The moment I started to use chlorine in conjunction with the algae I got the combined taste and odor of the two. Our consumption downtown was reduced 50 per cent, nobody could use the water. The moment you attempted to drink a cup of tea in the morning you would immediately grab your nostrils and walk off and leave it alone. I do not see where the application of chlorine would be justified as a reducer or eliminator of the algae taste.

E. E. DAVIS: We had a sad experience with algae in Richmond, in June, 1914. The water that supplies our settling basins is taken from the James River, at a point one mile up the river. There is an island, and around the upper end or point, the water flows to the feeder of the sedimentation basins. Near the lower end of this island there is a diversion dam which gives us a head for the feeder. The

rest of the water of the river flows down on the south side. The river was low at this point, and at times there was no water flowing over the diversion dam. At this time the Board of Health reported some 27 cases of typhoid fever in the city. I took the matter up with Mr. Beck who was a member of our Administration Board and an engineer, and explained to him what the trouble was, lack of fresh water. After looking over the condition with him he offered a resolution to our Board instructing the Superintendent of Water to do what was necessary to remedy the trouble. I built a rubble dam from the island to the southern shore of the river thereby diverting as much water as possible to the north shore of the river. By so doing the water was raised high enough to flow over the diversion dam on the north shore, thereby getting a good flow of fresh water into the basins. We sometimes find algae in the sedimentation basins. We use copper sulphate or blue stone by filling bags and fastening them on a boat, so as to drag them under the water.

J. M. Diven: The speaker's experience in copper sulphate treatment has been long and varied. Very soon after Drs. Moore and Kellerman gave this valuable information to the world, a reservoir of which I had charge developed algae trouble and Mr. James M. Caird, who at the time was in charge of the filter plant at Elmira, New York, applied copper sulphate to that reservoir. At that early day we probably lacked confidence and were very cautious. I remember that I insisted on not using the treated water for several days after the treatment; fortunately we had another source of supply. In fact, the reservoir water for some time before the treatment had not been fit to use. The treatment was entirely successful, and that reservoir has been copper sulphate treated many times since.

My next experience was with a large and shallow reservoir in the South, where algae are active ten or more months each year. The reservoir covered some 2000 acres and had an average depth of about 8 feet. We first attempted to treat the entire reservoir, paying particular attention to the shallow places, the little inlets and bays. Algae grew rapidly and were very thick in such nooks and the idea was to destroy it at its source. But the surface to care for was large and such treatment proved very expensive. Afterwards, this water was treated near the pump intake in a radius of 500 to 1000 feet. Some additional treatment was given in the intake, where a very

small quantity of copper sulphate was applied. Mr. James E. Gibson has fully described the treatment of this water. His treatment is practically the same, except that we did not treat the water in the clear water reservoir, never having had any trouble with algae there. When cleaning this reservoir, however, we washed the walls with a rather strong solution of copper sulphate and also with a solution of hypochlorite of lime. After this washing the sides were washed down with strong hose streams to remove any surplus of the disinfecting solutions used.

My next experience was with a large and deep reservoir in the North. The reservoir had a capacity of eleven billion gallons and a maximum depth of 58 feet. Algae gave trouble only for a short time in the summer. The shores were mostly abrupt with few hiding nooks for the algae and the treatment was mostly in the shallow places where the algae began to form, killing at the source. Owing to the large surface to be covered it was found advisable to use a motor boat. This hurried and cheapened the work, requiring less men and considerably less time. It also made the application more effective, as it kept the water that was being treated well agitated, helping the mixing of the solution. We had an idea that much less of the copper sulphate was coated with sediment in the water and carried to the bottom, we got more benefit from the amount used and possibly might have reduced the quantity applied, but no experiments were carried out to determine this.

Some fish were killed in all cases. All three reservoirs were stocked with black bass, but the fish killed were mostly bullheads, suckers, carp and other mud fish. Very few bass, pickerel or other game fish were affected. This is possibly due to the fact that the treated water is harmless, but that the mud fish got the copper sulphate that had settled to the bottom, as it is their nature to root in the mud bottom.

STATE LICENSES AND TRAINING SCHOOLS FOR FILTER OPERATORS

Dow R. Gwinn: I understand that the state of Texas requires filter operators to have a license; they put them through a regular examination before they are allowed to operate filter plants. I do not know that any other states require licenses for filter operators.

John Chambers: The State Board of Health in Kentucky is quite active and a bill was introduced in the last legislature giving the State Board control of the design, construction, maintenance and operation of all plants, whether municipally or privately owned. The bill was defeated. The Louisville Water Company opposed that portion which provided for the control of the design, construction, maintenance and operation, but invited such examinations of the water delivered to consumers as the Board of Health should see fit. Of course there was a great deal of opposition from privately owned companies. I do not see how it would be possible, except perhaps in the eastern states, to provide a training school for filter operators. I mean the men who actually operate the filters and not the chemist or bacteriologist. The Louisville Water Company's chief chemist and bacteriologist has control of the treatment of the water. He is a man of excellent executive ability and technical knowledge. The filter operator must serve an apprenticeship before he can be left in charge of operation. Of course, any preliminary education which he might obtain would be helpful.

Francis D. H. Lawlor: We have comparatively few filter plants in Iowa. The filter plants are mostly in the southern counties of the state; in the central and northern parts of the state their water supply is mostly from wells, so it is not a live issue in our state.

W. C. Hawley: No license is required in our plants in Pennsylvania at present. Our plans and specifications have to be approved by the State Department of Health, and the State Department keeps a close watch on the operation of the plant and on the results. We report weekly.

ALEX MILNE: There is no license required in Canada and no instructions are required. The Provincial Board of Health at Toronto, the headquarters, have a laboratory with a filtration plant, rather in miniature, installed there, and the recommendation of the Provincial Sanitary Engineer is that in the event of a new filtration plant being installed on a city service, that their services are given gratis to training any operators you send to them. I would rather imagine from Mr. Dallyn's action that it will not be very long before training is required for filter operators. It is leading that way now.

GEORGE W. FULLER: In New Jersey they are required to be licensed for both water and sewage purification works.

DOW R. GWINN: Good; that makes two states.

A. V. RUGGLES: In reply to the question as to whether filter operators are required to be licensed. A license is not required in Ohio. The engineers of the State Department of Health make periodic visits to the several hundred filter plants in the state and do a great deal of good, spreading the gospel of best operating practice and new methods and discoveries. The Ohio Council of Filter Plant Operators holds a meeting every year, which is very well attended and valuable, and where excellent papers are presented and open discussion is had on matters of filter operation.

E. E. DAVIS: We have a Supervisor, who is a chemist, at our settling basins. He makes a daily report to the Director of Public Utilities, our boss, one to the State Engineer, who looks after all the purification plants in the state, attached to the State Board of Health, one to the Director of Public Welfare, our city's Health Department. They check him up. I know of no state law requiring a license. Our plant is one of the old style sedimentation and coagulation. We have under construction an up-to-date filter plant, of 30,000,000 gallons daily capacity which we hope to have in operation by the first of July, 1924.

SERVICE PIPES: WHO PAYS FOR INSTALLING, REPAIRING AND MAINTAINING?

WARNER C. BROCKWAY: The standard water service in use in Duluth, Minnesota, is $\frac{3}{8}$-inch lead pipe. Lead pipe $\frac{1}{2}$-inch in diameter is the absolute minimum sized pipe that will be installed. Larger sizes will be put in, in accordance with the schedule of higher prices, if the consumer so wishes.

Originally gas services were made of one inch iron pipe. When renewals are necessary, $1\frac{1}{4}$-inch galvanized iron pipe is used. The original cost of service connections is paid by the consumer. Renewal of connections is at the expense of the water department. A renewal is better than an original service that the consumer has paid for, which constitutes a burden to the water department.

Instances are on record where services installed have not been used, so that no revenue for water has been received by the department. When such services must be renewed, it is clearly a financial burden to the water department. The connections extend from the main to a point one foot inside of the curb line.

The basis for the charge for the house connection made by the water department is from the center of the street, even though the main may be located on one side of the street or the other. In some cases, of course, the city loses money, but in other cases, the city makes money. It seems that this method is equitable for all concerned. If a water service line only is installed, the cost is $1.80 per foot. A charge of $2.00 per foot is made when both gas and water services are laid. Rock removal and paving charges are added.

The work of laying pipe from the curb line to the house fixtures must be done by a plumber, hired by the owner of the property. The water department inspects the work of the plumber to the point where the meter is installed. The question arises as to who should pay for the added cost of the renewals over the cost of the original service.

OSCAR E. BULKELEY: I should like to bring up another point regarding services, namely, installation of services ahead of pave-

ments. This is becoming a real burden in many cities on account of the large paving programs which are being carried out. In Lansing the Water Board pays for the cost of installing all services up to the curb box. Every lot is given service before the street is paved. Often there are a great many vacant lots, and, therefore, services after installation remain inactive, many of them possibly for a number of years. When finally there is a demand for this inactive service it may not be found large enough or it probably is not in the right place. There are a number of indefinite things about such installations, so that the speaker has questioned the advisability of installing services for all vacant lots ahead of new pavements. I should like to know what the experience and practice of others has been.

JOHN CHAMBERS: I think we have an aggravated case of that kind in Louisville. There is an ordinance, using the language of the city charter, which provides, before a street is constructed, that every lot must have installed a water, gas and sewer service. A notice is served on each property owner allowing him twenty days in which to secure the service. If he does not comply with the terms of the notice, and he is not compelled by law to do so, he cannot secure a permit for disturbing the street pavement for the installation of any kind of service whatever until the five-year guarantee period on the street pavement has expired. Many complications result. The Louisville Water Company usually installs most of the water services as there is no charge for the installation whatever. If, however, the service does not yield revenue at the end of one year the owner of the property for which the service was installed must pay to the water company the cost of the installation. Requests for services that were not installed before the construction of the street are quite frequent, and in some cases very appealing, people having purchased lots on which to build homes only to find out that water service cannot be obtained.

F. A. BUNKS: In the laws of this state (Michigan) is a section which may be of benefit to the gentlemen. I refer to paragraph 3094, Section 8, of Compiled Laws, State of Michigan. Briefly, all persons owning lots, land, etc., adjoining to or abutting upon any street, avenue, etc., before same shall be paved, shall lay all sewer, water and gas connections and carry same beyond the curb line as

the Council shall determine necessary. Should the owner neglect or refuse to make, lay or put in such connections at the time and in the manner prescribed by the council, then the council shall cause the same to be made. The respective owners of such lots, etc., shall be liable for the cost thereof together with a 10 per cent addition thereto as a penalty. The cost and penalty may be recovered by the city in an action of debt of assumpsit, or shall be reported to the Board of Special Assessors, to be levied and assessed by them as a special tax or assessment upon such lots, etc.

Oscar E. Bulkeley: There may be such a law; it was, however, referred to our City Attorney who evidently was not aware of the existence of such a law.

W. G. Patterson: The gentleman is right on the law in regard to installing services and making assessments, because in Highland Park we install services on all vacant lots before the pavement goes in, and if they are not paid for within one year there is a special assessment and we collect it with the other city taxes just the same as we would a paving tax or a sidewalk tax. It becomes a lien on the property.

John Chambers: In our case (Louisville, Kentucky) it is not a lien on the property.

J. N. Chester: It is a local question and depends on whether it is a private water company or a municipality. The Pennsylvania Public Service Commission says to all private companies, "You must lay to the curb line at your own expense, the service, furnish the shutoff cock, and if the city or borough want to charge you for taking out a permit, you must pay that." But I live in the city of Pittsburgh and they would not even furnish a corporation cock. I paid for everything, including the corporation cock being put in. Some cities have ordinances requiring the property owners to put the services in ahead of the paving, and some cities have ordinances making the water companies put services in ahead. I do not believe in putting services in ahead, I had one experience at Lyons, Iowa, where services were required to be put in ahead of pavements, and instead of the town growing up to the pavement, it went back and hundreds of services stood for years unused, and then leakage set

in and they all had to be taken out. But I think it is a local question depending on the state laws, city ordinances and municipal or private ownership.

OSCAR E. BULKELEY: The expense must be borne by some one. The speaker was informed by Mr. Brush that in New York services are not placed unless a consumer is already assured; if uncertain, the pavement is placed and later on the consumer pays the extra cost of installing the service on account of digging up and replacing the pavement.

Answering Mr. Chester, that may be local to New York, nevertheless the expense of installing a great number of services is saved. They are not installed until actually used. This matter is of vital importance to every water works, whether privately or municipally owned.

J. N. CHESTER: If it lies there idle ten years, it will cost 100 per cent more.

OSCAR E. BUKELEY: Surely, and looked at in that light, it would seem better not to install such services previous to the laying of pavement. The larger economic aspect of the problem should be considered. Perhaps also the psychological effect of continually excavating through comparatively new pavement is also important and perhaps is difficult to measure in dollars and cents.

W. S. CRAMER: We have a considerable development in Lexington, Ky. In fact almost all our development now is just outside the city limits. We started three years ago on a new proposition of running the water main in the parkway between the sidewalk and the curb stone, and it was provided in the deeds to the property that we had the right to dig up in front of your house to tap the main for across the street and use a pusher to go under the street. Our soil is fairly heavy clay and this provision worked out very nicely. We have one residential district that has something like 22,000 feet of pipe, and I should say today it is 80 per cent tapped. We have no trouble tapping and it has gotten us away from putting the service in ahead of street pavement. We had developed prior to that inside the city, and I think on something like 250 taps that were put in, we have 37 there now that will never be used. In selling the lots

in that locality, I do not know whether that is customary elsewhere, the lots are all 25 foot lots, you cannot buy less than two, but you can buy as many as you want on a bid on the price per foot. You bid on a lot, say $30 a foot. You cannot take less than two lots, but you can take three or four or five, and in bidding that way we have some houses that were built on 60 foot lots, some on 75 and some that have gone the extreme the other way and put two bungalows on a 75 foot lot. In that way we lost 37 taps in that one development. It is occasionally possible to run 15 or 20 feet from that tap to strike another man's property line, but you still have the tap in front of the other man's lot. It is not regular or desirable in any development of that sort. In the change of the frontage a man finally uses, you have a number of taps that will never be used.

W. C. Hawley: It seems to depend on whose bull is gored. If the municipality has to foot the bill they do not put them in; if the property owner or the water company has to foot the bill, they are ordered. I had an experience a few years ago, when the railroad tracks through the town were raised and some of the streets depressed and permanent pavements laid in those streets. The borough authorities ordered us to put in service lines in front of all vacant lots. We told them we did not put in service lines, that was up to the property owner. The property owners had more votes than the water company, so they decided that the borough would put in the services. The borough authorities decided where the services should be put in, the size, etc. Since that time a great many of those lots have been built on and there were just two of those service lines that were in the right location and of the right size, the rest were too small or were not where they were wanted. Recently our company began to put in service lines without charge to the consumers. The borough is doing some paving and we have been requested to put in service lines. After discussing the matter, we are putting in some lines where we know they are going to build. In some cases where we do not know whether a building is going up or not or what kind of a building or what size service they are going to need, we have compromised on this basis; we put in a six inch sewer pipe, and then when necessary to put in a service line, we can dig down to the main, put in the corporation cock and put the service pipe through the sewer pipe to the curb, whatever size is needed. In that connection, we are putting all our service lines now through sewer pipes so that

when the permanent pavement is put down it will not be necessary to tear up to find a leak, the water will come up through the curb box and we can then go to the main, disconnect, dig down to the curb stop, pull the pipe out at the curb, fix it and put it back.

Answering Mr. Cramer's question, the sewer pipe is as expensive as service pipe, but it will be cheaper than tearing up the pavements and we hope to avoid the criticism which tearing up the pavement causes.

W. S. CRAMER: If they let me go to the main, I will get the service in all right; we can put them in with a pusher if they let us go to the main.

W. C. HAWLEY: We cannot do that in our soil.

W. S. CRAMER: Not long ago a friend of mine came to me and wanted a service put in. I said, "Have you got any particular place to put it?" He said, "Yes, I want to put it on the south side of the lot." I said, "You had better put it in the center; you might change your mind about the house." "Oh no. I am going to put the house on the north side of the lot." We put in the tap and in a few days he came back and said, "You will have to move that damn tap; I took the old lady out there and she changed *our* minds; we are going to put the house on the south side of the lot."

J. M. DIVEN: Mr. Cramer spoke of running the water main in the parkway, between the sidewalk and the curb. But this space in residential districts is usually occupied by shade trees and digging to the main to make a tap or repair a leak is apt to disturb, injure or possibly destroy a shade tree. Shade trees are something dear to the heart of many people and they resent any injury to them, in fact in many cities they are protected by ordinance. I vividly remember an experience with a water main laid in this way when a lady appeared with a dog and shot gun and ordered us not to disturb her shade trees. In this case the leak was directly under a tree and it was necessary to tunnel under the tree roots to get to it. We abandoned the work until our attorney could reason with the irate lady and explain the situation. I did not in the least blame the lady for her position, for the tree was a very beautiful one. We finally managed to repair the leak and save the tree, but it proved an expensive job.

I do not think it is usual to put services in ahead of a pavement on a basis of 25-foot lots in residential districts, for it is seldom that so narrow lots are sold or built on. Even on a 50-foot basis they do not always hit the right place, even if they happen to be the right size. I remember an occasion where services put in for 50-foot lots proved wrong, as the 100-foot making up two lots was finally divided and built on as three lots. In this case two services were joined just inside the curb line, and third service taken off the connecting pipe. This tided over the difficulty and saved digging up the newly laid pavement. But, though there was a distinct understanding with the three property owners about the care of the two services from the main, including an agreement between them as to ownership, I can see possibilities of trouble some day.

One more word on services put in to save tearing up pavements and before the property is improved. These services are necessarily "dead ends" and have no circulation. After an unusually severe winter at Troy, New York, when the frost went below the depth expected and provided for, below the 5-foot mark, 55 dead services were found frozen in the spring and had to be dug up and repaired, disturbing the new pavement quite as much as putting in a new service of the size and in the location wanted.

Henry P. Bohmann: We aim to get in all underground structures in Milwaukee before putting down a permanent pavement. The last year a district was annexed to the city, and immediately we proceeded to put in water mains and sewers and bring the water service up to the curb. I was very much surprised to learn from Mr. Brush that this is not the practice in New York. In this particular district, the services were extended to the curb immediately before putting down the pavement. I do not think in this district that there will be a single lot without a house on it inside of two years.

E. E. Davis: In Richmond we run the sewer in the center of the street, the gas pipe on the north and east and the water on the south and west, and if a new pavement is to be laid the telephone company, the telegraph company and the power company are notified to put in their underground work. The city puts in the sewer and assesses the property ten cents a front foot on each side. The property owner pays for sewer connections. When the gas pipe is connected there is no charge for the connection, but there is for the water connection.

When a man comes and signs the book, he is required to return to us a piece of lead pipe the same length as we put in.

J. M. DIVEN: The south side of the street is all right in a climate like that of Richmond, but in the north the water main would be more comfortable on the north side of the street where it would get the benefit of the winter sun. I think those living in northern cities have noticed that the snow and ice disappear earlier in the spring on the north side of a closely built up street, as the buildings on the south side shade the street for a longer time each day.

DOW R. GWINN: In Terre Haute we are required to lay the service pipe up to the curb at our own expense, provided a man will agree to take water for one year. In that case we maintain it and take care of it forever. In case of what we call improvement services, the city engineer goes over the street before the contract is let, usually with our men, and he decides where he wants laterals, as they call them, put in. We make out the list for him. Then he gives that list to the contractor, ordering the contractor to see that those services or laterals are provided before the street is paved. The contractor then comes over to the water works office and pays $7.00 for each one of the $\frac{5}{8}$-inch service pipes that are to be put in. He pays in advance, although he sometimes objects and says, "I do not get my money in advance," but he pays in advance. Then the lateral may lay there for ten or fifteen years without being used. That is the hard part. The water department or company has got to be responsible for that service pipe, keep it repaired and provide the water for the leaks, if any occur. You may not see them, but they are going on just the same, and in the meantime it may be fifteen, twenty or twenty-five years afterwards that somebody will connect to it and perhaps it may be in a wrong place, and nobody will connect on it. In the meantime perhaps they have had to resurface the street, so it is pretty hard to tell just what is the best thing to do. We dislike to see them tear up the newly paved street right after it has been paved. On the other hand, it seems a pity to allow the service connections to stand there for a long period of time and not be used, even though we do get $7.00 for it, for $7.00 does not begin to cover the cost.

CHARGES FOR PRIVATE FIRE PROTECTION SERVICES

Dow R. Gwinn: There was a gentleman here this morning, I do not know his name, and he said that he had compiled the water rates for private fire protection for 250 cities, and they went all the way from nothing up to $1000. Take your choice; I will take the $1000.

John N. Chester: I can say that I have compiled fire protection rates for 50 cities. For hydrants we charge the same as we charge the city, or in the city, in the municipal plant, we probably would not charge anything for hydrants. For the private company we charge them the same as the city, and they lay the pipes to the property line. For a sprinkler system, we charge the same service charge that we charge for anything else per opening, and we would not allow anything else to be attached to it. That service charge would not be less than $50 for a 4-inch pipe. For that service charge, we would give them sprinkler heads at the rate of 5 cents apiece, and if they have sprinkler heads enough to exceed the service charge, we would charge them 5 cents apiece for them. That is a general rule that may be modified to fit conditions.

Henry P. Bohmann: Ever since I have attended the water works conventions I have found this subject coming up each year. There seemed to be so much opposition to it that I almost got cold feet trying to introduce a charge of this kind in a city where this service had been furnished gratis for many years. I picked up courage, however, about two years ago and introduced a charge in the city council and it passed. We get $25 for every 4-inch connection, and $50 for every 6-inch connection. This gives an additional revenue of about $12,000 or $13,000 a year which we did not get before. With the first bill I sent a letter giving court decisions, railroad commission and public utility orders to justify this charge, and while I had two or three inquiries, everyone paid and we have collected the second year without any protest, so that up to the present time we have collected over $25,000 from a source from which

we did not get anything before. I anticipated a great deal of trouble, but it worked out very nicely. I want to say that all our services are metered except the automatic sprinkler. We have about 250 automatic sprinklers in service and it would be pretty hard to compel them to change to meters at this time, because I know the Association of Commerce would get busy with the city officials and I would have to stand alone. I know that I would go down to defeat.

Answering Mr. Chester, the consumer has the alternative of installing a meter and paying only the regular service charge of $20 per meter per year. The cost of installing a meter on a fire line is rather high so that the interest on the investment will amount to as much as our annual charge on the unmetered service. The annual charge really ought to be more, but it is one of the hardest things to introduce a charge of this kind where heretofore no charge was made. That explains why so many cities make no charge for this kind of service.

J. W. Toyne: The plant at South Bend, Indiana, is a municipal one, and for public fire hydrants we collect from the city $40 per hydrant per year. We make the same charge for private hydrants for fire protection, sprinkler, etc. We have a sliding scale or a service charge varying from $2.00 per month on a 2-inch line up to $10 per month on a 6-inch line. We make no charge for the water used in fighting fire. However, we do not allow any connections to these lines other than the sprinkler head.

W. S. Cramer: You will find as you go into this thing that most of this opposition and all this ammunition your citizens have to fight you with and the number of quotations they give you are furnished by contractors. A contractor will go to a man to furnish him a sprinkler outfit, and he will agree to put it in on the saving in insurance rates that it will make over a given term of years. If he can pinch you for any revenue, he gets by that much quicker, and he has got a whole armful of documents there and can show you where this place does not charge anything for installation or anything for service, glad to have them, welcome them. He picks those cases and he immediately gets busy. If this man is of a little prominence or has any pull, he gets busy, but when you fortify yourself and take with you that this is an outsider entering here and he is working for his own gain, it puts another face on the matter. It does not make

any difference to him particularly whether this goes over a longer period of time. The equipment man wants to get it over as soon as he can. If he can put it over in six years, why give nine? That is where most of the opposition comes from. It is the argument they give your citizenship in talking up the business.

HENRY P. BOHMANN: I should like to see all these services metered. The insurance men, however, go to the manufacturers and tell them they will not get as good a rate if meters are installed.

W. S. CRAMER: I think you have done fine; you have talked to me about it before, and I think you have done fine.

DOW R. GWINN: We have a minimum rate of $22.50 a month for a 4-inch connection for a private fire protection service. That rate was fixed by the Public Service Commission of Indiana. We allowed $22.50 worth of water for the minimum rate, so if the customer uses that much water his fire protection is not costing him anything. It is a pretty good thing to have a meter on private fire hydrants and be on the safe side.

JOHN N. CHESTER: Are those inside their building?

DOW R. GWINN: They were out in the yard, on their premises.

JOHN N. CHESTER: If a man will steal water from his yard hydrant, he will steal it from the street hydrant.

DOW R. GWINN: At one particular place, a meter reader went to read the meter and found a hose connection running inside the plant, and he said the hose seemed to be standing full all the way. We got $2000 from that man in one year, and he never complained. He used to complain about $20 a month, but when he paid $2000 a year he did not kick. Another concern paid us I think $700 the month before last, and their bill this month will be fully as great as the month before. We might as well get the money, there is no use furnishing those people water for nothing.

W. C. HAWLEY: I should suggest that Mr. Bohmann tap each side of the gate valve and put in a meter on the by-pass and without

anybody knowing it close the gate valve. You will not find all of them stealing water, but you will find a great many, so many that you cannot afford to furnish private fire protection without its being paid for. We tried it out the first time in Wilkinsburg, Pa., just to see what would happen. I induced our people to purchase an 8-inch detector meter. We put it on a private fire line and were surprised to find that water was being taken all the time through the by-pass meter. To make a long story short, we found that their large office building with all of its plumbing was connected to that fire line. When it was connected, nobody knows, nor how long water had been taken. In another case I tapped around the gate valve and tried it occasionally. We found at every test that water was being taken at the rate of $\frac{2}{3}$, $\frac{3}{4}$ or 1 cubic foot per minute, and even more. After a while we happened to get there at the right time and found that they were taking water at the rate of 4 or 5 cubic feet a minute. We put a detector meter on that line and we got a very handsome revenue from it. It was several years later before we found that they had a connection to those fire lines and were using water deliberately in large quantities at special times. Those are just two instances, but I can tell you of others. In these cases, as a rule, it is not the management that is responsible, but some plumber or foreman who needs a new water supply and taps the most convenient pipe.

Dow R. Gwinn: I am for the little fellow. We charge a minimum rate of about $1.00 a month. Where a man has a small house and does not require larger than a $\frac{5}{8}$-inch meter, we charge a minimum of $1.00 a month. If you will put the capacity of a 4-inch fire line meter along by the side of the capacity of a $\frac{5}{8}$-inch you will find that the capacity of one is a hundred and fifty times greater than the other. Now, if you charge the little fellow $1.00 a month minimum, what right have you got to let the other fellow off for the ridiculous sum of $5.00 or $10.00 a month? It looks to me as if he has that much capacity tied up with your pumping outfit and he ought pay somewhere near in proportion to what the little fellow is paying.

John N. Chester: You should have a graduated service or minimum charge, and impose it on all people alike.

Dow R. GWINN: Away back in 1906 a certain manufacturing concern in Terre Haute started litigation in connection with a fire protection line, and he dilly dallied along with that thing until 1912. Then Mr. Chester came out and testified in the case and the court decided in our favor, that they had no right to demand fire protection except under special contract, and that we could shut the water off if we wanted to. We gave them a little opportunity to appeal the case and they did not appeal it, so we shut the water off, and in order to make it effective, we cut out a piece of the pipe. Then they appealed the case, and the Supreme Court decided it against us on our contract, because the contract said a man could buy water in such quantities as he desired, and on that little technicality the Supreme Court decided in favor of the plaintiff, that is, to this extent, the case was referred back to the original court for retrial. It was never tried again, because in the meantime we had a public utility law and the commission decided that every private fire protection line should be metered. We have a minimum rate of $22.50 a month on a 4-inch meter, and last summer we had another case with this same company. That time we got Mr. Cramer to come up and help us, and when the commission got through they ordered that the manufacturing company was not entitled to a 6-inch connection, that is, what they were demanding. We said we would give them a 4-inch connection, but we did not like to jeopardize the general fire protection for the sake of one concern, that our duty first was to the citizens and that the general fire protection was paramount, so the state commission ordered that we should not allow anybody to have more than a 4-inch connection unless we came before the commission and received special permission to allow something larger. Oh, it is a big problem, but the public has some rights that should be considered.

The committee appointed by this Association a few years ago went into the matter very thoroughly, and they cited, I think, about 15 cases where the water mains had been bled by the breaking of automatic sprinkler pipes; they also cited about a dozen cases where the public water supply had been contaminated through the private fire protection line, where they had their own pumping plant and forced polluted water into the mains, which resulted in quite a number of deaths, in one Illinois case. They cited a case where it cost the manufacturing company $100,000 through the compensation law on account of the deaths of its employees due to drinking the polluted water.

FRANCIS D. H. LAWLOR: It is a bit off the subject, but we had a little experience this spring. There was a very hot fire in a building that was not sprinkled. It was separated from a sprinkled risk by a 12- or 13-inch wall. The sprinklers in the building that was not on fire opened from the heat. It was a dry system and when those sprinklers opened, our engine ran away. I should like to ask if any of the gentlemen have had experience with their pumping engines starting to run away when the sprinklers open?

DOW R. GWINN: Yes, in our case it was due to the breaking off of the 6-inch line that the concern had at that time. The sprinklers did not put out the fire.

FRANCIS D. H. LAWLOR: Perhaps the sprinklers were the dry system and I thought that the air might get out through the sprinkler heads faster than the water, or perhaps when the check valve opened on the sprinkler system, the water in going in might create water hammer and compress the air, which surged back or something of that kind might have taken place. At any rate, the engineer on the watch reported that when these sprinklers opened, his engine started to run away. He was standing at the throttle at the time. We have direct pumping and the maximum speed governor shut the engine down during the fire, but of course the man was there and started it immediately.

DISCUSSION ON REPORT OF THE COMMITTEE ON METHODS AND RECORDS OF WATER WASTE CONTROL[1]

William W. Brush: In the Journal there has been printed the progress report of the Committee, and it is the desire of the Committee that the members read that report and give us the benefit of their experience in water waste prevention, water waste control, size of tap and services, etc. The report defines the various classes of waste and indicates the methods that have been followed in measuring and locating waste and in stopping waste.

We all know that waste exists in every water supply system. This country has developed rapidly and like all rapid growth it has been a growth in which much consideration has not been given to the smaller savings. Now we need to conserve to some extent and we are willing to conserve; perhaps not as willing as we should be, but the conservation of water is to be a more and more important question as time goes on and our water supply becomes more and more difficult to secure and more expensive. In the determination of whether water waste does or does not exist, the first question is that of consumption, and the really useful consumption figures are those that are most difficult to get. You can prove almost anything as to the consumption of your own individual community, if you will take the consumption figures throughout the country based upon the per capita and simply say, "Oh well, now here my community has a consumption which is such and such, and here are all of these other places that have a greater consumption. Therefore, we have a pretty good system." But that does not prove anything. You need to have your total night rate and your day rate; the night rate and day rate consumption of your larger consumers, the ones that use water for commercial purposes during the night hours, and compare the two and determine whether your night rate is down to a reasonable amount, when you consider the character of population you have to serve and the number of miles of main in the system.

[1] Report printed in Journal, May, 1923, page 468. Discussion at Detroit Convention, May, 1923.

If you determine that your consumption is too high, then it is a question whether it is too high on account of the waste of water inside the buildings or whether it is too high on account of leakage outside the buildings, or too high on account of both. If you go after the leakage outside the buildings, then you will either determine by pitometer the flow through the mains, subdivide your distribution system and find the suspicious locations and chase down the actual leaks which cause the high flow in those sections, or you may adopt the method of sounding and using an aquaphone to determine leaks. You may adopt the method of measurement of flow from hydrant to hydrant by closing a valve and using hose and meter to connect the two hydrants, or other methods. The methods mentioned are the more usual.

As far as waste in the building is concerned, you have the question of metering or examining the building and determining whether there are leaky fixtures and having the fixtures repaired. In addition to water waste control, your Standardization Council has seen fit to turn over to this Committee the question of the size of services, taps and meters. There are comparatively few data available in the published records of the transactions of the American and the New England Water Works Associations. It will be necessary to get from the different communities and the men in charge of water works just what they do in determining the sizes of taps and services. From the conversations I have had with superintendents, it seems to me that none of us have a very good method of determining the size of taps; it is "by guess and bigosh," largely bigosh, that we determine the size of a tap. Gradually the practice has changed so that five-eighths inch is virtually the smallest size tap that is used. I know in Brooklyn in years gone by the tap was made as small as the men in charge thought they could possibly get away with, and the service was made as small as possible. I asked one of the old hands why it was done and he said, "Well, we keep it that way so that we will keep as much water in the mains as we can." That is all right from the viewpoint of not having to go after more water supplies, but it is hardly service. I think we certainly should determine some reasonable way of getting at the size of the taps and the size of the service, the size of the connection to the house that will give to the occupant of the house good water service. That is what they want, that is what they need, and it is a mistake to cut down below the size that will give good service.

It does not mean very much leakage or loss of water because a man has a large tap and large service; when a leak occurs, you are as a likely to get it on a large service as on a small service, except that on a large service the pressure does not drop quite so much. That is the only factor, the delay in knowing of the leak on a service if it is a large one, the loss of head is mainly in the service. Your entry head is your source of loss in the tap, and that is almost negligible.

It is quite a common practice to limit the size of the tap and to let a man put in almost any size of service he wishes. That is not very intelligent, but most of us do it, and we ought to do it more intelligently. When it comes to the meter, we are inclined to put in oversized meters. That is not necessary, because the meter may be changed readily at small expense, but you cannot change the tap or the service without digging up the street and causing annoyance to the people who use that street and running into a large expense, either to the owner of the property or to the water company or the municipality or whoever may bear the expense. The amount of water which gets by through under-registration or lack of registration in the meters is large, just how large depends upon the character of use and size of the meter. I think that you will find that generally our meters are larger than is necessary, and we ought to reduce the size of the meter so that we will record more accurately the amount of water delivered and get a more adequate return for the water actually used in the building.

Chairman Fuller: We have some other members of this Committee who perhaps have personal experiences to state. I am going to call on Mr. Bohmann of Milwaukee.

Henry P. Bohmann: The tentative report made by this Committee shows conclusively that there is no short-cut method for controlling water waste, but that it needs an intensive campaign day in and day out. Even in a completely metered city, one cannot sit down and wait for results; if you do, your waste of water will surely increase. It would be very desirable if comparisons could be made with cities that are all metered, but here the difficulty arises as to what methods are used in presenting these figures. Some cities estimate their slippage of pumps at 15 per cent; others at 5 per cent. Then there is the great difficulty of arriving at the

amount of unmetered water. There are certain services which it is not practicable to meter, and these usually are the hardest to control. All large cities have services that are extended to the curb only, where also the house drain is extended and where many times leaks exist at the curb cock and water gets away in the drain pipe and does not show on the surface. The larger the city, the bigger the problem, because there are thousands of services extended for future use.

In Milwaukee we found it necessary to take out of the hands of the plumber the furnishing of the curb cock on account of the poor article furnished, which was the cause of a great deal of leakage. In the absence of all services being metered, I think about as accurate a method of arriving at whether the department is going forward or backward is to divide the pumpage into the total revenue received for water and arrive at your revenue per million gallons pumped. This method can be used by a city whether it is all metered or not. In the City of Milwaukee we started a campaign for the elimination of waste some ten years ago. At that time the revenue was $45.80 per million gallons pumped. This campaign was conducted for ten years along the same lines by men connected with the department at very little expense, and we were able to increase the revenue to $50.50, although there was no increase in water rates during the entire period.

In trying to control water waste, it is necessary to begin at the pumping station and first to ascertain whether the amount delivered into the distribution system is accurate or whether there is too large a slippage of pumps. Next, in cities where you have reservoirs there are leaks the amount of which it is very difficult to estimate. In the City of Milwaukee we have many large coal yards where they have fires in the coal piles, and in order to save the expense of calling the fire department, we give them a hydrant wrench and they are to report the amount of water used, based on the length of time the hydrant has been open. Naturally, we must assume that they report the correct amount. Then there is the use of water from fire hydrants by contractors which is very difficult to control. In some small cities I understand they are metered. In Milwaukee we frequently have 50 to 60 contractors engaged in street work of different kinds such as sidewalk construction, curbing, sewer work, street construction, etc., which makes it practically impossible to meter this kind of service. There is the paving and

repairing work done by the street car company between its tracks, which is done all over the city. We cannot expect the company to trouble water consumes all along the line to get the use of water, the company naturally uses the fire hydrant and we take its report as correct. The city itself uses water and this is almost as difficult to control as some of the contractors, because the other departments do not appreciate that it is necessary to get this information. If you wish to show the amount of water you are to account for, and each department is obliged to pay for its water, some will endeavor to keep it down to the minimum and report less than is actually used. You see the amount of water that is unmetered is more difficult to estimate than the metered water, and the difficulty of getting on a comparable basis with other cities unless they are either all metered or it is on the basis of the revenue per million gallons pumped.

I think Mr. Brush said that large cities, and for that matter small ones, ought to ascertain the night and the day consumption and use that as a basis, ascertain whether the consumption at night is too large and whether it is due to leakage in the distribution system and services, or whether there is a legitimate use during the night. I know that in Milwaukee there are many large industries that work day and night, and, therefore, it would be necessary to check up their day consumption against the consumption during the night period, in order to arrive at whether it is waste or legitimate use.

CHAIRMAN FULLER: We shall be glad to hear from any other members of the Committee who joined in this report.

EDWARD S. COLE: I want to bring out one important point. We cannot overemphasize the desirability of deducting the metered industrial use when we try to compare the per capita consumption of different cities. Many cities have the large metered accounts in separate books, and it should be possible to total these books as representing the trade use and to deduct it from the total consumption. This is not ideal, but it is a long step in the right direction. What is left is, of course, domestic, commercial and unaccounted for, but if we may conveniently total the metered manufacturing water and take that out, we shall approximate the ideal of segregating all but domestic use. I think it would be helpful if some of the executives and superintendents who are here would tell us what,

in their opinion, would be the cost of getting the data for the Committee for general use. If you would state how much you think it would cost to total the large meter accounts of your city, the information would be interesting and valuable.

CHARLES S. FOREMAN: As the Committee Chairman has stated, it is quite some job to obtain the necessary data and properly to analyze the same, to determine whether a water system has very much waste of water.

Along the lines Mr. Cole has just mentioned, we are endeavoring, in Kansas City, to classify all water accounts by going through all the ledgers and placing a classification letter on each account, indicative of the character of service. That is, whether commercial, manufacturing, residential, etc. At each meter reading period, after the amount of money is run on the adding machine, the amount of water consumed by each service will be run on the same machine. To do this it has been necessary to have a special twenty-nine column adding maching constructed.

After all of the accounts have been classified, the letter indicative of its class will also be run on the adding machine, with the amount of water consumed. This report, giving the total consumption of each class, and the total amount of water accounted for by meter, is sent to the Engineering Division.

It cost approximately $2600 to classify the accounts. Not very much benefit may be derived from such a system at first, because of no previous records for comparison, but as the data accumulate they will increase in value.

All water works superintendents should be considerably interested in standardizing the methods used for determining the size of taps and services. It is rather difficult in most cities to have any definite rule laid down, because of the variation in water pressure, as is the case in Kansas City, where the pressure varies from 150 pounds to as low as 30 pounds, depending upon the elevation.

We have a great many complaints from consumers bcause of low pressure and when an inspection is made to determine the cause, we usually find that the consumer's service is far too small to supply the amount of water required. In Kansas City, we have no rules regarding the size of service to be permitted, except that it shall not be less than three-quarter inch. That is, we allow the plumber to make application for any size of service that he may desire, without

regard to the character of the consumer's premises and without regard to the amount of water to be used.

There are many different methods of determining the size of tap and service, such as the floor area method or the number of openings. However, these methods will not apply to each individual city because of the varying conditions in pressure and service.

I think that, if the Committee might get the ideas and experiences of all of the water works superintendents, it would help considerably in formulating standard methods for the determination of the size of services and taps.

Dow R. Gwinn: In Terre Haute we carry about 45 pounds pressure in the residence district for houses up to eight rooms. We give them a five-eighths tap and a five-eighths lead service up to the curb, furnished by the company free of charge. Ordinarily the plumber carries a three-quarter inch line from the curb into the house. We find that arrangement gives very satisfactory service.

In regard to the production of waste, when we were 10 per cent metered, we were pumping about 1550 gallons per consumer; now that we are 98 per cent metered, we are pumping 550 gallons per consumer. In order to keep a record of the demand at night, we take a record of the output between the hours of 2 and 4 o'clock, when most of the people have stopped using water, except the railroads and large manufacturing concerns. In our engine room we have a graph which the engineer keeps up each day showing the revolutions per minute of the pumps for that period in the night. When the engineer sees that curve go up he realizes that something may be wrong with the pump, maybe a leaky valve. It suggests that he get busy and examine the pump before his attention is called to it from the office.

Caleb Mills Saville: What Mr. Brush said is quite interesting, and fits what has been the popular thought about the loss of water through under-registration of meters. That question has become quite important and we have been considerably troubled by it as related to demands for larger meters. Houses that were formerly adequately supplied by tank closets got along very nicely with a five eighths meter and a three-quarter inch service pipe. After many complaints we found, after a good deal of investigation,

that the maximum rate usual for that house was about 1½ cubic feet per minute, and that would be only for five minutes or so, happening perhaps several times during the day. The ordinary consumption would be much less than this, would be quite low, and it would very nearly be what our standard is on the low flow of that meter.

With the advent of flushometer closets, however, came a new demand, and it was found that those same houses which formerly used 1½ cubic feet per minute were now demanding a maximum of from 3½ to 4 cubic feet per minute. With this came the demand for larger meters. "Please put on larger meters. The plumber says that this is the trouble in my house; the plumbing fixtures and the plumbing are all right, everything is right in the house, but the meter is too small. Now he knows." Perhaps he does. In some cases we put on the larger meter, but the call has become pretty loud and it seemed desirable to investigate. Of course, we all know that a larger meter, a three-quarter or one-inch meter costs more money than a ⅝-inch meter. That is one argument against the change, but I had supposed and I used as an argument that there would be a great deal more unrecorded water passing through an inch meter than through a ⅝-inch meter. It seemed logical to contend that as you could not expect meters to be built like watches and have them function perfectly, the larger the meter the less would be the registration on the low flows. Within the last month we have connected up at our yard four of the standard makes of meters. The Hersey, the Trident, the Lambert and the Worthington, five-eighths, three-quarter and one inch size of each, twelve meters in all, discharging into a tank where the water could be carefully measured. I will not give you the details of these tests, but I will say that we started with a flow of 0.02 of a cubic foot per minute, which seemed to be about what might be expected from a leak in a toilet, and continued this flow for about twelve hours. Some of the meters registered better than others on that flow, but they all registered something. I think three of them registered within 92 or 93 per cent. The next run was at a rate of 0.12 of a cubic foot per minute. Everyone of these meters ran well within the limits of the meter specifications. At a rate of 0.08 of a cubic foot per minute they all did as well. The thought came that, perhaps with intermittent flow such as one would get during the day, we might get some differences, so a man was as-

signed to work them all day. He started at 0.02 cubic foot per minute, then changed over and ran 4 cubic feet per minute, for a minute or two, then dropped to 1½ cubic feet per minute, then down to 0.08 cubic foot per minute, for an hour or so, and so on. When the test was completed we found that even under these conditions they all measured satisfactorily. So far as could be seen from that test, there was no appreciable difference in the registration of amounts of water passed through any of those meters. You will recall that they were ⅝, ¾ inch and 1 inch sizes of each standard make. This test clearly indicated that larger meters were just as sensitive as small ones in registering low water flow.

JOHN N. CHESTER: I am fast becoming an advocate of a very liberal service. As Mr. Brush says, you can change the size of the meter, but it is difficult to change the size of the service. As many years as I have lived, and it is approaching sixty, until I built my own house last year I never lived in a house that I did not consider underplumbed. When you are trying to take a shower-bath and somebody else draws water you either get a cold douche or are scalded. At a plant in which I am interested, we have a high place in the city and when the sprinkling hour arrived it became necessary to shut off the standpipes and turn on direct pressure. The superintendent was constantly howling for reinforcement for that district. He bought a lot and built his house out there and I suggested to him that he plumb his house liberally, at least that he bring a liberal line in from the street. Acting on that suggestion he put in a one inch line and a one inch meter, and he made the confession when I was last out there that he had never found a shortage of water in his house, that he had plenty of pressure and plenty of volume.

I have made it a rule, in the three plants we operate, that they shall use nothing less than a three-quarter inch corporation and three-quarter inch line clear into any house. I have removed altogether the restrictions as regards what size the service shall be, protected as we are in every case by a graduated minimum or a graduated service charge. There is the schedule, we say to the consumer, take your choice and you will pay for what you take in the way of a minimum or service charge. We will reserve the right to fix the size of his meter commensurate with what his maximum demand may be. While I appreciate Mr. Brush's problem and others in

large cities where they have large office space, in Jefferson City a seven-story building is the tallest thing we have had to tackle. We have had nothing more than the ordinary industrial and commercial work, and it is not hard to fix the meter size for them, but the meter size in residences is fixed much more by the plumbing than the square foot of area or the number of people in the house. It is more likely to be the number of bath rooms and the maximum demand that can be made upon the service, than any other one feature. Now the last thing is the flushometer closet. That came to my attention about ten years ago, and I have made the same recommendation always, a graduated minimum and a graduated service charge, and let them have what they want and use it as fast as they can. Of course, I had one client who said, "We have only a four inch main on that street and about four houses connected flushometer closets in a block and our service is gone." I said, better connect up the other end of your four inch and feed it both ways, but do not admit to your customer that he cannot have water as fast as he wants to pay for it.

JOHN CHAMBERS: At the present time the Louisville Water Company is having made by the Pitometer Company of New York a pitometer survey of the entire city. The engineers of the Pitometer Company have been working for five or six months and have covered possibly one-third of the city. The engineer in charge of the work reports that he has never found in any city where he has made a survey a superior underground condition to that in Louisville. But one joint leak has been discovered, wasting 370,000 gallons daily. There has been found, however, a disgraceful condition of house waste. There are about fifty-three thousand services and possibly six thousand of these are metered. It is not at the present time the policy of the Louisville Water Company to meter small services, the water being paid for on an assessment basis. All large services of course are metered. I personally do not agree with the Board of Water Works in the matter of metering, but hope that there will be a change of policy at some time in the not too distant future.

Some examples of extraordinary waste will be interesting. The public schools and charitable institutions obtaining free water are the greatest wasters. The Boys High School wastes one hundred and fourteen thousand gallons per day. This is not consumption,

but actual waste. Another school wastes one hundred and four thousand gallons per day, and still another wastes seventy-eight thousand gallons. At this time all of the schools have not been examined, but there is reason to believe that conditions will be found bad in all of them. In order to reduce the high waste, two inspectors are working under the pitometer engineer making house to house inspections and serving forty-eight hour notices threatening either to install a meter at the cost of the consumer or to shut the water off. The threat to install a meter is not seriously meant, and if the repairs are not made within forty-eight hours the water is shut off according to the notice served. This system has brought remarkably favorable results and it is probable that in seventy-five or eighty per cent of the cases the repairs are made within the allowed time. It is proposed to increase the number of inspectors in order to cover the entire city before the pitometer survey is completed.

William W. Brush: The question has been asked as to whether we have found anything better than the aquaphone in locating leaks. We have not found anything better than the aquaphone. We have used a form of stethoscope, but have found it unsuited to New York City conditions, due to the noise in the city streets.

As a Committee, we desire from the members of the Association:

1. The night consumption between 1 and 4 a.m.
2. The percentage of the night consumption due to large commercial users.
3. The consumption for the twenty-four hours.
4. The experience with leak prevention work.
5. Rule followed in determining the size of tap to be allowed.
6. Rule for determining the size of service to be allowed.
7. Rule for determining the size of meter to be installed.

There is one paragraph in the report that I should like to read to you as long as we have time; it is in reference to the varying cost to the community for water that is wasted;

> An illustration of the varying cost to the community of the water which is wasted is afforded by New York. When the Catskill system was first utilized in 1917 and about 375 mgd. made available, the Brooklyn and Richmond systems were placed in reserve and the draft from the Croton system was cut in half. The cost of any additional water delivered by gravity from the

Croton system was about $0.25 per million gallons, as this cost was limited to the chlorine required to treat the water, the system of collecting works, aqueducts and distribution mains being adequate to deliver the additional quantity to provide for the waste of water, and no additional force being needed to operate the system.

I find that a good many get an erroneous idea of a statement of this character, and yet I do not see just why that should be so. The water cost at that particular time, the additional amount of money that you have to spend in order to provide that water, has absolutely no bearing upon what that water costs, based upon the cost of constructing the works, and it has virtually no relation to the amount that it will cost you perhaps four or five years from now for additional supply. When a million gallons of water costs you 25 cents, you cannot show any economy in stopping the waste of that water. In New York we estimate that we can stop waste at the present time by our special gangs at about $3.00 a million gallons, but it does not pay us to go into the area supplied by Croton gravity and pay $3.00 a million gallons to stop waste, if that waste at that particular time is causing no damage. It does not mean that at some future day we may not have to stop such waste, but at the present time if a million gallons cost 25 cents and it costs us over $3.00 a million gallons to stop that waste, we should not spend our time and the city's money in stopping that waste at this particular time.

If the Croton water had to be pumped, as would be the case where waste occurs on the higher ground, then the cost of the water has been about $10 per million gallons. If Brooklyn water had to be drawn on to make good the waste the cost increased to about $25 per million gallons, and when the Richmond supply was needed for this purpose the cost was about $40 per million gallons. When New York reaches the time when the construction of the works for an additional supply beyond that from the Catskill system must be started, and that time is close at hand, then each year that the starting of such construction is safely postponed, due to stopping waste, would mean a saving of over $10,000,000 per year, which would make the value of the water then saved over $500 per million gallons. Care must be exercised in the use of any figure like the one last given, as the delays in carrying through any enormous water supply project like that needed to serve New York for another twenty years growth are such as to necessitate the time allowed

being determined with several years leeway, if provision for the future is to be safely made. In other words, you cannot attempt to draw the line in developing supplies that take you a dozen or fifteen years and say "This is the time we ought to start construction," when you consider the various difficulties that may be in the way, both in starting the construction and carrying it through to successful completion. But there is a period when you are adding to your source of supply, when water saved represents a very high value per million gallons, and in a system like New York or other large cities, where you have to add your additional supply in large units, there is a time when the cost to the municipality of the water being wasted, that might be saved by water waste work, is very small. As we view it, the intelligent method to be followed in stopping waste under such conditions is to go after the waste that, when stopped, costs us less to stop than it does to allow the waste to continue.

David McLean Hanna: Mr. Brush asked a question with respect to the use of the electric leak locater. I have had a short experience with the use of the electric leak locater and find it is very useful where there is known to be a leak. By following up the service to the main, you can get directly over where the water is leaking, without breaks in the pavement of any kind, and therefore it reduces your cost of repairs by your being able to make your excavation immediately over where the water is leaking. You can dig right down to the leak and make the repairs at a minimum cost. It is necessary to do the work, of course, during the night period. The instrument is so sensitive that if there is any interfering noise you cannot get the result; everything has to be perfectly quiet; you cannot use it while there is rain falling. We started out one evening to make a test, and just as we got the instrument set, it started to rain and we had to close up shop and come back the next night to locate it. I believe it would be adaptable to following up mains to find leaks where you think there are such, by traversing along over the top of the main during the quiet hours.

DISCUSSION OF REPORTS ON PUMPING STATION BETTERMENTS[1]

LEONARD A. DAY: Some of these questions will be replied to by letter from some of the men who are qualified to talk along these matters. Our Committee thought that possibly this evening we might bring out discussion on some of these subjects. Our articles on condenser performance and removing oil from boiler feed water have been published, and I presume it will be of no benefit to read them again tonight. I should like to have some discussion on the subject.

CHAIRMAN FULLER: Is it not a fact that your Committee is following the policy of trying to take practices as revealed by recent installations and put into the JOURNAL a summary of what those particular arrangements may be? And the particular topics on which later arrangements might be desired are what you want to get the views of the membership on?

LEONARD A. DAY: In our department we have recently experimented with powdered fuel on a small scale. A company in St. Louis loaned us a pulverizer and we built our furnace and worked up the details of the apparatus considerably. Our experience with pulverized fuel is not very gratifying. I think, however, that our experience would not be conclusive as against the better practice of pumping stations in general, because we were limited by conditions in so far as the design of the furnace was concerned. We were handicapped in not being able to dry our coal, which we found to be an absolute necessity. Our coal in St. Louis runs as high in some cases as 15 per cent moisture, and if you attempt to pulverize coal with that moisture content, you simply cannot do it. Your pulverizer chokes up and your energy for pulverizing the coal runs up about 100 per cent above normal, so that we found we would have to dry our coal if we were going to pulverize it. We also found that where we

[1] JOURNAL, September, 1922, page 696; January, 1923, page 145; September, 1923, pages 882 and 883.

built one furnace and did not provide any means of cooling the walls, we burnt the furnace down in about two or three days, just simply melted it down. On the next one we put in hollow walls, designed a system of hollow walls and took the air for combustion through these hollow walls. That seemed to solve the problem. In modern plants, however, that is carried on to a further extent than we did. At the Lakeside Plant in Milwaukee, the air for combustion is taken from the entire boiler setting. They also have what they call water screens in the bottom of their combustion chamber, by which they had practically eliminated slag, and slag is one of the biggest bugbears in pulverized coal. We found that a furnace volume of around $5\frac{1}{2}$ cubic feet per boiler horse power was necessary.

John N. Chester: I should like to ask Mr. Day if it is not his conclusion that the use of powdered fuel, like the use of stokers, does not become practical until you get a plant of a certain horse power, say 1000 h. p., and over, that it would require that big a battery in order to return the fixed charge and the upkeep out of the savings and to make it otherwise practical to be employed?

Leonard A. Day: There seem to be two types of pulverized fuel apparatus, one type which is applied in the larger central power stations in this country and which undoubtedly is not suitable for the ordinary boiler plant, until we reach a boiler horse power of approximately 5000. From there on up the power plant designers claim they can just about break even with the stoker fired plants. I talked to Mr. Mayo yesterday at the Ford Plant. They have, of course, a wonderful system of pulverized fuel there. He said that pulverized fuel installation was just about equal to that of a good stoker installation; that is, when you consider the cost, you get more economy. I think that is true in most all the modern pulverized fuel plants, but you have to pay for it in the way of initial investment. Mr. Mayo's thought there was that there was nothing in the furnace, no moving parts whatsoever in the furnace, but he has plenty of moving parts previous to the furnace. However, it is a wonderful plant, a wonderful installation of pulverized fuel. They burn three kinds of fuel, coal, by-product gas, and coke-oven gas and tar; and sometimes they burn all three fuels at the same time.

JOHN N. CHESTER: How about the necessity of a more intelligent man in charge of the plant during the operation? Do you have to have them with stokers or hand-fired furnaces?

LEONARD A. DAY: I am inclined to think you probably do not need as intelligent a man. For firing a stoker, he must be a pretty intelligent fellow in order to get the best out of it, but you approach a condition of burning gas in a pulverized fuel which is easily set. They were running as high as 19 per cent CO_2 at the Ford Plant yesterday. Of course in ordinary stoker practice, if you average 9 or 10 per cent, you think you are doing pretty good, and the party we spoke to in the plant was surely lacking in ordinary boiler intelligence. We asked him what his flue temperature was and he said 1200 degrees. He was kind of groping around in the dark, he did not know. There has to be a master mind in a plant of that size, but for ordinary small plants, where you might decide to put in a unit type of pulverizer, I think the ordinary boiler room attendant can get along with it all right.

CHAIRMAN FULLER: Your second proposition, Mr. Day, was the driving of a low head pump by water wheel with water lead from a force main into which water was delivered by highly efficient pumping units.

JOHN N. CHESTER: I had some tests made at Jefferson City some time ago to decide whether or not we were warranted in continuing driving our coagulant mixing apparatus by means of a water motor or had better abandon it and take electric current and buy our current at three cents. I think we can save at least 50 per cent of the cost of the energy by so doing.

CHAIRMAN FULLER: The next one, Mr. Day, was the question of the boiler baffling, vertical or horizontal baffling.

LEONARD A. DAY: I might say that as far as our practice goes, we have pretty well concluded that the vertical baffled boiler offers greater advantages than the horizontal baffled. We all know now that combustion engineers are making some wonderful strides in the design of furnaces to keep down as much as possible the cost of furnace repairs and to bring up the efficiency of the boiler and furnace.

The vertical baffle offers a decided advantage in that; if you put in one of the baffles commonly known as the Turner type of baffle, you immediately expose practically half of your tube surface to the radiant heat of the boiler and furnace. That has a tendency to keep your brick work cost down and to keep your furnace temperature a little lower. The radiant heat is quite beneficial in so far as economy of the entire unit is concerned. I think the horizontal baffle boiler was popular in the olden days because it was rather an easy baffle to handle, but unless you use the third baffle in a horizontal baffle boiler, which is more or less complicated and especially in old plants cannot be done very well, the vertical baffle seems to be much better.

W. S. Cramer: I should like to ask Mr. Day if the test on a small plant would be acceptable, if you could get anything from them? We have two seniors in the Kentucky State University who have a thesis on boiler plants this year. We have a Stirling Boiler of 265 h.p. that has a hand fired stoker, and a 250 h.p. fire tube horizontal boiler. One has a shaker grate and one has a plain grate. In making those comparisons we were advised to put in a stoker. This is a plant that is carrying a load of a million and a half gallons as a minimum, and during that time if we are operating a Stirling Boiler, we have to hand-fire it, we cannot even hand stoke it. If I had to go over it again in this plant, I do not think I should put in the hand stoker. I think the best thing is a good shaker grate. I shall be glad to give you those facts if they will be of any use to you.

Leonard A. Day: I appreciate that, Mr. Cramer. One is a hand stoker and one is a hand fired grate.

The next proposition dealt with was steam pressure and superheat. We attempted to bring this question out because everybody else is doing the same thing and there does not seem to be any limit to steam pressure and super heat now, according to the rumors that are floating around in reference to the power plants being designed. It is only natural that water works practice follows along somewhat the same lines as power station practice, in so far as economies go. What we are anxious to know is, when does it cease to pay? What steam pressures are the most economical steam pressures, and how much super heat? The central power station practice now in a good many cases is going up as high as 700 degrees total temperature. I have

been advised that the ordinary waterworks type of turbine is not adapted or rather will not show any appreciable gain in economy when steam pressure is greater than 250 pounds and 200 degrees super heat is carried. That is a subject that we might have discussed by some of the turbine men here if they care to.

Another thing is the temperature of the steam cylinders. If you are using reciprocating engines, the pumping engine people are inclined to draw an arbitrary line at 550 degrees total temperature. That might be a steam pressure of 200 pounds and 200 degrees super heat, somewhere in there. I understand recently, in fact I saw an engine being built in one of the leading shops not long ago, that was going to carry a total temperature of 630 degrees. So it looks to me, in order to be fair to the reciprocating type of unit, that you could not arbitrarily say that that unit was only good for 550 degrees total temperature and the other types of units were good for 600 degrees, without at least an investigation.

JOHN N. CHESTER: I think we are most of us bound up by what we have.

CHAIRMAN FULLER: Now and then they build new stations, you know.

JOHN N. CHESTER: The question Mr. Day raises is one for the new stations. Naturally there is a difference between the temperature you can carry in the reciprocating engine and one that will be consistent in the turbine, for in the reciprocating engine we have got the valves and overheating of the oil and a good many things like that, all of which we must consider. Like powdered fuel, however, it introduces other complications that sometimes, before we get through, eat up economies that we have created by increasing our temperature and the pressure of our steam. I do not believe the limit of pressure and temperature has been reached in turbine practice, and that is borne out by the fact that pretty nearly every big central electric station built over-steps everything else before it. But when we come to talk about 500 and 1600 h.p. units of boilers and stokers, it is very different from what Mr. Cramer has down in Lexington where he has put a stoker under a 250 h.p. boiler and where I would not expect him to reach any other conclusion than the one he has drawn. I bumped my head the same way; I found that out by experience.

CHAIRMAN FULLER: Mr. Day and Mr. Chester, is it not a fact that these are the propositions on which your Committee welcome suggestions, and if anyone has any special interest in them, you want to bring out the latest advanced information for the benefit of the members of this Association? I do not believe we are going to gain a great deal by trying to discuss these things academically here tonight, but I do want to express my appreciation of and full sympathy with the idea that we have got a real live committee on pumping station betterments. Anybody that has any idea that they want to bring up at a later meeting or at any time to be put into the report of this Committee should communicate now with Mr. Day.

REPORT OF COMMITTEE NO. 10 ON STANDARDIZATION OF SERVICES

Your Committee on Standardization of Services found the subject rather more complicated than they expected. The chemist of the Committee was asked the seemingly simple question, "What degree of hardness is necessary to make it safe to use lead pipe." This question brought up many complications and other chemists have been added to the Committee to make a more exhaustive study of this subject.

Your Committee decided to divide the proposition into two heads, the mechanical, dealing with various materials for services and the chemical. The latter will take up especially the use of lead pipe from the health point of view.

In the mechanical field many new elements have entered, the centrifugally cast pipe in small sizes, small sized cast iron pipe with prepared joints, cement lined pipe, etc. These are all questions that we cannot report on before sending out a questionnaire and getting data from the users of various kinds of service pipes. We want information concerning the cost of services and their lasting qualities and we can get this only from the users of the various materials.

It is not the intention to deal with the sizes of services for various service, but we do propose, if possible, to get some information concerning the demands made by the introduction of the flushometer water closet and the demand it creates for larger service pipes.

We will endeavor to get some information on the strength of lead pipe. We now buy lead pipe by classes, A, AA, AAA, etc., getting about the same thickness of shell for all sizes, the same for a $\frac{5}{8}$- as for a 2-inch. Either we are buying too much lead when we buy $\frac{5}{8}$-inch or too little when we buy 2-inch, unless we adopt a system of using a different class for each size. The attempt will be to classify lead pipe much the same as cast iron is now classified.

Your Committee understands that it is expected to find out and report on what is the best material for services from all standpoints, health, durability, cost, etc., and if the questionnaire may be sent

and receive proper attention, exact replies and data, the information thus obtained may be tabulated and embodied in a report.

B. J. Bleistein,
G. C. Bunker,
R. E. Greenfield,
C. D. Howard,
R. B. Morse,
George Read,
M. C. Whipple,
S. DeM. Gage,
J. M. Diven,
Chairman.

DISCUSSION

Chairman Fuller: Gentlemen, this question of lead poisoning is something that is attracting a great deal of attention in England, as I found this past winter. A rather sad feature is that some of the water works people in England have actually died from lead poisoning. We have made quite an effort during the last few months to get hold of someone who has the courage, time and patience to look through those English reports and find out what the controlling points are in respect to the solubility of lead by waters of different types. I know when I left Massachusetts some thirty years ago and went to Louisville, Kentucky, to live, I found right away that lead pipe when it was brand new was dissolved by the Ohio River water, but after a little while it got a coating of basic carbonate, which was impervious. That shows the difference between soft waters in New England and the water of the Ohio River; but where the dividing line is between a water which gives trouble to the point of corrosion and even to the point of bringing about lead poisoning which is cumulative, and those which form quite readily this basic carbonate, I do not know. To stop lead poisoning, in some instances they are adding precipitated chalk, what I would call carbonate of lime, and making it a regular feature of the treatment of the water supply, in order to bring about an increase of hardness.

This Committee is one that, as Mr. Diven has said, is clearly at a stage where they have two divisions, a mechanical and a chemical division. On the mechanical side, they want to go ahead with a questionnaire. I am fully in sympathy with it, and also with their desire to get practical information on the chemical end. It

is going to take a lot of time, but it is a well worth while proposition. Waters highly charged with free carbonic acid as from the Memphis wells, means that one of our tasks is treatment to keep carbonic acid down low so as to make that water literally kind and gentle. I think Mr. Diven has said enough to indicate that you have an interesting set of topics in the hands of this Committee.

Charles B. Burdick: I should like to ask what is the character of those waters in England that are causing that lead poisoning trouble, and why is it that that trouble is only coming to a head at the present time, at this late day.

Chairman Fuller: I think there are three characteristics. There is high free carbonic acid, in the first instance. In the second instance there is a group of what I might call organic acids, humic acids. Decayed leaves and decayed vegetation generally will produce substances which have an acid reaction; they tend to add their mite. The third element is that there is insufficient bicarbonate or normal carbonate which will produce this coating of lead oxide and lead carbonate which forms this natural protective coating. In other words, you have the two corrosive elements in this water, and the absence of enough hardness to bring about the coating which stops the corrosion.

It was investigated by the Local Government Board of England, corresponding, perhaps, to our United States Public Health Service, over twenty years ago. It is not a novelty, but they have been more watchful lately. I think Alexander Houston was in charge of this work for the Local Government Board (now the Ministry of Health) that has supervisory powers on water expenditures, so that no municipality can issue bonds for water works improvements unless the project meets the approval of this central agency. Those English reports are available in print. It is a time-consuming job to brief them, but it is well worth while. These Committees under the Standardization Council are doing good work. It is gratifying to the Standardization Council to have you discuss these reports and ask questions. If questions occur to you after you get home, write to the chairmen of those Committees. Let us keep going and bring out a set of committee reports that will make the beginnings of a manual that it is the ambition of the Standardization Council to produce to set forth standard water works practice in America.

Rudolph Hering

Died May 30, 1923

Rudolph Hering, born at Philadelphia, Pa., February 26, 1847, was a son of Dr. Constantine Hering, a prominent physician and one of the leaders among German-trained medical men who founded Homeopathy in this country. In 1860 he was sent to Dresden where he attended the public high school and later the Royal Saxon Polytechnic Institute, from which he graduated in 1867 as Civil Engineer. Returning to the United States, he found work at Prospect Park, Brooklyn, and later assisted in the laying out of Fairmount Park, Philadelphia.

Numerous cities in this country suffered at intervals from severe epidemics of yellow fever. With few exceptions, sewerage arrangements in this country at that time were both meager and faulty and far below European practice. Mr. Hering was commissioned by the National Board of Health to make a thorough investigation of European sewerage practice. This engaged his attention on the ground in large representative cities of the principal European countries and led to the preparation in 1881 of what is doubtless the most important report ever appearing in this country as to the fundamental principles and arrangements of structures for the satisfactory removal of household wastes by water carriage.

Following his return from abroad, he began his consulting practice, although from 1882 to 1888 his time was very largely devoted to three important engagements. The first was the supervision in the field of an exhaustive study of new sources of water supply for the City of Philadelphia. In the second, from 1885 to 1887, he served as Chief Engineer of the Chicago Drainage and Water Supply Commission, which was created to recommend a method of keeping the sewage of the city out of Lake Michigan. These investigations were an important step in the creation of the Chicago Drainage Canal. His third large investigation was in New York City where he reported to General Newton as to betterments to the basic design used for the

local system of collecting sewers and also on arrangements of the outfall sewers, which on his advice were gradually extended from bulkhead to pierhead lines in the City of New York.

Although the structural aspects of engineering had been of principal interest to him perhaps during the first ten years of his active work, he had the vision to see that it was important to keep abreast of the times, not only with regard to the earlier recognized phases of engineering, but also in the allied subjects of biology and chemistry.

Although Dr. Hering was one of the first to recommend mechanical filters for pumping the water supplies at Atlanta, and elsewhere, and was connected with important water supply investigations at New York, Philadelphia, Washington, New Orleans, Columbus, Montreal, Minneapolis and numerous smaller places, his accomplishments were greatest in the field of sewerage and sewage disposal and led to his having been designated years ago as the "Dean of Sanitary Engineering" in this country. Recognition of such standing was perhaps first made by President Harrison, who, in 1889, appointed him Chairman of a Commission to prepare a program for sewerage improvements for Washington, D. C.

Dr. Hering was an active worker on the committees of various professional organizations as well as civic movements. His most important work was undoubtedly that for the American Public Health Association in the matter of the collection and disposal of refuse. He gathered statistics as to results of operation and otherwise elucidated practice in this country and Europe. Some twenty-five years ago he gave liberally of his own time and money for gathering information upon this subject, although his activities in the field of water supply and sewerage did not permit him to publish the results of his investigations in the disposal of solid wastes of the municipalities.

Dr. Hering was in partnership with George W. Fuller, M. Am. Soc. C. E., from 1901 to 1911 and with John H. Gregory, M. Am. Soc. C. E., from 1911 to 1915. After the latter date his activities were confined largely to work upon a book on "Collection and Disposal of Refuse" of which he was a joint author with Samuel A. Greeley, M. Am. Soc. C. E.

His kindly interest in helping young engineers was a lovable trait which he revealed to many, both in this country and abroad, and thereby he proved to have been a strong inspiration to many a struggling young engineer. He had an unusual gift of learning what

was new in European practice and in bringing the principles back to this country and stating them in a way that their usefulness might be available to his co-workers in America. By many he was considered the foremost of American engineers in teaching his associates to be wisely guided by developments abroad.

He received an honorary degree of Doctor of Science from the University of Pennsylvania in 1907, and an honorary degree of Doctor of Engineering from the Polytechnic Institute at Dresden in 1922. He was a member of a large number of engineering societies both in this country and in Europe. He was an honorary member of the New England Water Works Association and of the American Water Works Association and a Past President of the American Public Health Association. He became a member of the American Society of Civil Engineers in 1876, was Director in 1891, 1897 to 1899, and Vice President in 1900 to 1901.

He is survived by his widow and five children.

GEORGE W. FULLER.

DISCUSSION

AN ANAEROBIC, SPORE-FORMING FERMENTER

Since the publication by Raab[1] of a report of a lactose fermenting spore-former at Minneapolis, it seems worth while to add information developed on a similar organism in the laboratory of the Indianapolis Water Company.

This report is part of a paper presented to the Indiana Section of the American Chemical Society in November, 1918, on work done between the November and June previous.

The organism is a winter visitor, being seldom or never encountered during the warm months. This applies to fermenting spore-formers in general, 89 per cent of our isolations of them occurring between November and May.

Many anaerobic spore-forming gas-formers occur in raw water and are reduced in purification. They are noted only in sterilized water on account of the relative volumes enriched, and also since they grow poorly, or not at all, on the usual separatory media.

Sterilized water has lost many of the common aerobic bacteria and it often happens that endo plates made from gas-forming enrichments produce no growth whatever. Of more than 4100 positive presumptive enrichments of sterilized water, 43 per cent gave no growth on endo and only 10 per cent confirm.

Very frequently this butyric acid-forming bacterium is present in such enrichments. For three winters attempts were made to isolate it using the usual plating methods. Though large amounts of water and enrichments were plated and hundreds of transfers made, no gas-former was ever obtained.

In the winter of 1917–1918, in connection with other work it became very desirable to know more of this organism and a determined effort was made to isolate it.

Partial sterilization showed it to be a spore-former, but always mixed with a non fermenting spore-former, which could be isolated by plating in the ordinary way but not on endo. The non-gas-former

[1] JOURNAL, November, 1923, page 1051.

was found to be non-motile. In cultures of the two where gas was formed there was always motility noted.

After some failures with the old B. typhosus filter tube, the cotton plug in the U tube was replaced with fine sand. The motile gas-former is able to travel through it leaving the non-motile organism behind. However, if most of the sand is in the uninoculated arm, gas-formation in the filter medium may carry the non-motile one up and result in a mixed culture.

In this way a pure culture was obtained, but on transfer to new media it was found to grow only in milk. The mixed culture in milk produced coagulation and then rapid peptonization. The pure culture produced coagulation but no peptonization.

It was found that the fuchsin in the endo agar prevented the growth of the non-gas-former, and that in milk the gas-former could tolerate a fuchsin concentration of 1:30000. By transferring from a heated enrichment (to eliminate non-spore-formers) to fuchsin milk, growth of the gas-former occurred with no sign of peptonization. However from 3 to 6 transfers through fuchsin milk were required to eliminate the non-gas-former whose spores were carried along to new enrichments and had to be eliminated by dilution.

We now had two organisms, one of which would grow in milk and in no other medium except with the non-gas-former present. The non-gas-former, then, must modify peptone or sugar in some way to render it available as food for the gas-former. It is not a case of oxygen consumption on the part of the non-gas-former since incubation was carried out in freshly steamed media in an atmosphere of carbon dioxide. It seems to be a case of partial commensalism.

In enrichments of the water, gas formation is slow being noted only after twenty-four hours. In transfers of the mixed culture it is very rapid, often being vigorous in less than twelve hours, on account of the volume of inoculation and the physiological condition of the two organisms. Then the effect of the non-gas-former on the media is realized early. Standard peptone medium was inoculated with the non-gas-former and incubated for six hours. It was then sterilized, filtered, dextrose added and inoculated with the gas-former. In it the gas-former grew quite well.

In this medium, simplified by the non-gas-former, plantings were made using the following fermentable substances—*lactose*, *dextrose*, *sucrose*, *adonite*, *dulcite*, *salicin*, *galactose*, *maltose*, *glycerine* and *potato starch*. Of these only *lactose*, *dextrose*, *galactose* and *maltose*

were fermented. However, in actual combination with the non-gas-former it is able to attack sucrose and starch though the organism elaborates no measurable diastatic enzyme.

There has been no growth in any medium without fermentation.

The action of the non-gas-former was further demonstrated by growing it in plain broth in a collodion tube immersed in a tube of dextrose broth inoculated with the gas-former, which in this situation grew well.

The non-gas-former was known to have a proteolytic action on caseine. It was found also to act on gelatin, fibrin and nutrose. Only 0.05 cc of a seventy-two-hour culture was required to liquify 4 cc. of gelatin in twenty-four hours and 3 cc. dissolved 0.01 cc. of nutrose in thirty minutes at 37°C.

This opened up the matter of peptones and six were obtained for test. Ammonia was determined by distillation without added alkali and reported as per cent nitrogen. Amino acids were determined by the Sorensen method and reported in terms of cc. of N/10 NaOH per gram of sample.

PEPTONE	AMMONIA	AMINO ACIDS	GAS-FORMER GROWTH
Baker		6.2	—
Difco	0.09	20	—
Witte	0.01	11	—
Armour	1.47	30	+
Fairchild	0.5	27	+
Aminoid	0.7	55	+

Armour and Fairchild peptones were found to be higher in Tyrosine than the rest, but the difference was too slight to account for the great cultural difference. Ammonium sulfate added to unfavorable media had no beneficial effect. The chemical work indicates only that the organism requires a simplified peptone.

Lactose and dextrose broth containing dibasic sodium phosphate (or sodium hydrate) when sterilized at high temperatures, 15 pounds for fifteen minutes, were satisfactory media. Sterilizing the ingredients separately or in any combination of two, except sugar and salt, and mixing before inoculation gave an unsatisfactory medium.

Several freak media were prepared by adding a small piece of the material to tubes of distilled water and sterilizing. The following supported growth with gas-formation: liver, potato, beans, corn,

carrot, turnip, alfalfa, pumpkin seed, pumpkin meat, chard, beet, celery, onion, oats, rice, parsnips, and salsify. These did not support growth: raisin, prune, plum, California grape, apple seed, orange and applemeat.

Fermentable sugars must have been present in the fruits. Perhaps high acidity or the absence of available nitrogen prevented growth.

Microscopically the organism is 3.5 to 5 μ long and 1 to 1.5 wide. Spores form at the end of the cell and are larger than the cell containing them. In motile chains this gives the appearance of a head. Spores stain easily and are Gram positive. Flagella stain fairly easily with gentian violet (carbol) in vitro, but not with von Ermengem's or Loeffler's stain. Grows only with the formation of gas. It is anaerobic but may be grown in air in freshly steamed media. Ferments lactose, dextrose, galactose and maltose with the formation of acid and gas. Butyric acid is always formed in fermentation. It grows in many vegetable infusions and not at all in meat except liver.

It is non-pathogenic for rabbits and guinea-pigs, subcutaneously, intraperitoneally or by mouth.

The organism attracts undue attention on account of the butyric acid odor of its cultures. It is certainly non-pathogenic and seems to be of no sanitary significance.

C. K. Calvert.[2]

[2] Sanitary District of Indianapolis, Ind.

SOCIETY AFFAIRS

IOWA SECTION

The ninth annual meeting of the Iowa Section was called to order on October 24, 1923 by Colonel Edward Bartow, Chairman of the Section, in the Chemistry Building, Iowa State College, Ames, Iowa, with thirty-five members and guests present.

Dean Anson Marston, of the College of Engineering of Iowa State College, officially welcomed the Section to the campus of the institution. Chairman Bartow in reply expressed the appreciation of the Iowa Section of the opportunity afforded the Section to meet at Ames.

Max Levine then read a paper written by himself and Clair S. Linton, Research Assistant, "On the Differentiation of Human and Soil Strains of the Aerogenes Section of the Colon Group of Bacteria." The paper was discussed by Jack J. Hinman, Jr., C. O. Bates, A. M. Buswell and M. Levine.

A. M. Buswell read a paper entitled "The Microbiology of Activated Sludge," which was discussed by Chairman Bartow.

Edward Bartow followed with a paper on "Seasonal Variation in a Well Water Supply." The paper was discussed by A. M. Buswell, L. I. Birdsall and E. Bartow.

Dean S. W. Beyer, Dean of Industrial Science and Head of the Department of Geology, Iowa State College, addressed the Section on "The Geology of Water Supply." His talk was discussed by H. F. Blomquist and Chairman Bartow.

The Section then proceeded to the discussion of the topics listed for Round Table Discussion, as follows:

Tastes and Odors from Algae. Discussed by C. O. Bates, Jack J. Hinman, Jr., Earle L. Waterman, Thomas Healey, Frank Lawlor, A. E. Anderson, Dale L. Maffitt, Lewis I. Birdsall, W. R. Gelston, William Luscombe, W. W. DeBerard, S. E. Buck and E. B. McGlothlen.

The Section adjourned at 5:40 p.m. for supper, at which forty members and guests were present.

The Section assembled in the evening in the large lecture room of the Hall of Engineering. Papers were read as follows:

"Operation Records for Small Water Works," by Earle L. Waterman; discussion by H. V. Pedersen, Jack J. Hinman, Jr., R. H. Holbrook and E. B. McGlothlen.

"Supervision of Water Treatment Plants in Michigan," by Edward Rich; discussion by Chairman Bartow.

"Publicity at the Water Plant," by Jack J. Hinman, Jr.; discussion by Edward Rich.

The meeting adjourned until morning, when sessions were resumed at the Chemistry Building, October 25. Vice Chairman H. F. Blomquist presided. Papers were read, as follows:

"The Ames Water Supply," by P. F. Hopkins; discussion by C. S. Nichols and William Molis.

"The Iowa State College Water Supply," by C. S. Nichols; discussion by W. M. Householder, P. F. Hopkins and Max Levine.

"The Boone Water Supply," by Mr. C. L. Ehrhart; discussion by William Molis, Thomas Maloney, Wm. Luscombe, C. S. Nichols, H. F. Blomquist, P. F. Hopkins and Harry J. Corcoran.

"Shallow Wells," by H. V. Pedersen; discussion by H. F. Blomquist, L. I. Birdsall, C. S. Nichols and Wm. Luscombe.

Chairman Bartow announced the appointment of the following committees:

Nominations Committee: Frank Lawlor, Burlington, Chairman; Charles R. Henderson, Davenport, and Earle L. Waterman, Iowa City.

Resolution Committee: Thomas B. Maloney, Council Bluffs, Chairman; C. O. Bates, Cedar Rapids, and C. D. Hays, Huron, South Dakota.

Auditing Committee: H. F. Blomquist, Cedar Rapids, Chairman; H. V. Pederson, Des Moines, and A. T. Luce, Marshalltown.

The Section adjourned for lunch. During the luncheon, Chairman Bartow brought in Mr. George W. Fuller, President of the American Water Works Association. Mr. Fuller gave a short talk on the American Water Works Association and its benefits. Forty-five members and guests attended the luncheon.

The Section re-assembled at the Chemistry Building for the following papers:

W. H. Kimball's paper on "Settling Basin Improvements at Davenport" was read by title in his absence.

A paper not on the printed program was substituted for Mr. Kimball's paper. This paper was: "The Coöperative Work of the Omaha and Council Bluffs Electrolysis Committee"[1] by F. H. Patton, Division Supervisor of Plant Methods, Northwestern Bell Telephone Company, Omaha, Nebraska, and Chairman, Omaha and Council Bluffs, Electrolysis Committee. The paper was discussed by William Luscombe.

"Financing Water Main Extensions," by H. F. Blomquist. The paper was discussed by Thomas B. Maloney, George W. Fuller, R. H. Holbrook, A. T. Luce and Wm. Molis. It was moved by Royal R. Holbrook and seconded by C. L. Ehrhart that the incoming chairman be instructed to appoint a committee to push the bill introduced at the last legislature in Iowa, concerning the installation of water mains by municipal water plants, so that all extension first costs would not have to be met out of the funds of the plant, but that the costs of installation would be borne by property owners until the mains were actually used. Carried.

Harry J. Corcoran, Chief Engineer, Iowa Insurance Service Bureau, Des Moines, then read his paper entitled: "The Relationship of Water Works to Fire Insurance Rates."[2]

George W. Fuller, addressed the Section on the subject of the condition of the water works of Europe at the present time. After Mr. Fuller had finished his remarks, they were discussed by E. Bartow, Jack J. Hinman, Jr., S. E. Buck, H. F. Blomquist and E. B. McGlothlen.

The Auditing Committee, by H. F. Blomquist, Chairman, reported that they had examined the books of the Secretary-Treasurer and had found them to be correct. The report was accepted.

The Nominating Committee, by the chairman, Frank Lawlor, brought in the following ticket:

For Chairman—Mr. H. F. Blomquist, of Cedar Rapids, Iowa.

For Vice Chairman—Dr. Max Levine, of Ames, Iowa.

For Directors—Mr. L. O. Minor, Plattsmouth, Nebraska; and Mr. Thomas Healey, Davenport, Iowa.

It was moved and seconded that the nominations be closed and that the secretary be instructed to cast a unanimous ballot for the persons nominated. Carried.

[1] See page 72 of this Journal.

[2] See page 79 of this Journal.

The Resolutions Committee, by its chairman Thomas D. Maloney, brought in the following resolutions:

1. That the Iowa Section extend its thanks and appreciation to the Iowa State College at Ames, and to President R. A. Pearson, for the use of the Hall of Chemistry as a meeting place, and for the interest, help and coöperation given by individuals toward making the Ninth Annual Meeting successful.

2. That the Iowa Section extend its thanks and appreciation to the Engineering Extension Division of the Iowa State College for the manner in which it has coöperated in the preparations for, and the conduct of, the business of the Annual Meeting.

3. That the Iowa Section extend its thanks and appreciation to the Ames Chamber of Commerce for the use of its rooms and the many courtesies extended.

4. That the Iowa Section extend its special thanks to the Faculty of Iowa State College, and in particular to Professor S. W. Beyer, of the Department of Geology, to Professor W. F. Coover, of the Department of Chemistry, Professor C. S. Nichols of the Department of Civil Engineering, and to Director D. C. Faber, Mr. Royal R. Holbrook, Mr. Rolland Wallis, and Mr. Stanley Pinel of the Engineering Extension Division, for the courtesies shown to the Section and its individual members by these gentlemen.

5. That the Iowa Section extend its special thanks to Dr. Max Levine, of Iowa State College, for his excellent paper on the differentiation of important lactose-fermenting bacteria.

6. That the Iowa Section extend its thanks and appreciation to Dr. Edward Bartow, our Chairman, and to Jack Hinman, our Secretary, and that the Section record its pleasure to know of their recognition by the American Water Works Association at the National Meeting.

7. That the Iowa Section extend its thanks to A. M. Buswell, P. H. Patton, Edward D. Rich, Harry J. Corcoran, Earle L. Waterman, Hans V. Pedersen, H. F. Blomquist, P. F. Hopkins and C. L. Ehrhart for the excellent papers which these gentlemen read before the Section.

8. That the Iowa Section endorses heartily the proposition of Edward W. Bok in offering one hundred thousand dollars ($100,000) to any American who will devise a practical means by which war may be prevented between nations.

9. That the Iowa Section express its regret at the untimely death of Robert B. Wallace of Council Bluffs, and that the sympathy of the Section be sent to his bereaved family.

10. That the Iowa Section extend its most hearty welcome to each of its new members, and express its hope that each member of the Section now in good standing will endeavor to bring into the Association and the Section at least one new member during the coming year, so that the Tenth Annual Meeting may be even more enjoyable and beneficial through their attendance and participation.

11. That a copy of these resolutions be spread upon the minutes of the meeting and that copies of the pertinent sections be sent to the President of the Iowa State College and to other persons concerned.

12. That the Iowa Section express to President George W. Fuller its pleasure at having him present at the meeting and in having the opportunity to listen to his addresses.

13. That the Iowa Section extend its thanks to the Boone Chamber of Commerce for providing transportation from Ames to Boone and for other courtesies extended.

14. That the Iowa Section thank the City of Boone, and particularly the Mayor, and C. L. Ehrhart, the Superintendent of Water Works, for the opportunity to see the two plants belonging to the city and for the courteous treatment received.

It was moved that the report of the committee be accepted. This was carried unanimously.

C. L. Ehrhart moved that the incoming chairman be instructed to appoint at the earliest convenient time a committee to make a study of operation records for small water works and to endeavor to bring about the adoption of such records in the small plants of the state. The motion was seconded and carried.

This having concluded the business session, the Section proceeded to take up once more the Round Table Discussions:

Iron in Water Supplies. Discussed by C. S. Nichols and E. B. McGlothlen.

Water Waste Surveys. Discussed by Harry J. Corcoran, A. E. Skinner, S. E. Buck, William Molis and Thomas Healey.

Are Bookkeeping Machines Adapted to Small Water Works Billing? Discussed by H. F. Blomquist, A. T. Luce and C. J. Delacey.

Who Should Maintain Curb Shutoffs? Discussed by Thomas Healey, S. E. Buck, F. M. Johnson, E. B. McGlothlen and R. A. Douglass.

Corrosion of Hydrant Valve Stems. Discussed by R. A. Douglass, Thomas Healey, A. T. Luce, F. M. Johnson and H. F. Blomquist.

The Use of Flush Tanks in Sewers. Discussed by E. B. McGlothlen, Thomas Healey, William Molis and T. E. Nichols.

Payment for Water by City Departments. Discussed by A. T. Luce, George W. Fuller, J. J. Murtue, E. B. McGlothlen, A. T. Luce, Frank Lawlor, Harry J. Corcoran, William Molis, H. F. Blomquist and P. H. Patton.

The Section adjourned at 5:50 p.m. and the members and guests proceeded to dinner. After dinner they assembled at the rooms of the Chamber of Commerce of the City of Ames for a special enter-

tainment which had been provided by the Chamber of Commerce and the Ames Engineering Society.

The members of the Section assembled at 9:00 a.m. the following day, October 26, at the Chemistry Building of Iowa State College and were taken in automobiles to see the water plant of the City of Ames and the independent plant belonging to the Iowa State College, which supplies the college and also sells water to the City of Ames for the supply of the fourth ward.

At 11:00 a.m. automobiles from Boone were waiting at the Central Building of Iowa State College for the members of the Section on their return from their inspection of the Ames Plants. The Section had an excellent dinner provided by the Manufacturers Agents in the Elks' Club of Boone. After the dinner a musical program and dance was provided and a few of the members of the Section made short talks.

After the River Station of the Boone Water Department was inspected, the members were taken to the City Station. The meeting was adjourned and the members of the Section departed for their homes.

The attendance at the various meetings averaged between 45 and 50.

After the meeting the newly elected officers met and re-appointed Jack J. Hinman, Jr., to the office of Secretary-Treasurer. The Tenth Annual Meeting will be held at Iowa City, Iowa, by constitutional provision.

In a letter dated November 10, 1923, Chairman-Elect H. F. Blomquist has made the following appointments to the committees authorized by the Section at the Ninth Annual Meeting:

Legislative Committee on Assessment for Water Main Extensions: Thomas B. Maloney, Chairman, C. L. Ehrhart, Chas. S. Denman, John W. Pray, Wm. Molis, J. W. McEvoy, Phil. Carlin and George W. Shoemaker.

Committee on Operation Records for Small Water Works: Royal H. Holbrook, Chairman, Earle L. Waterman and E. B. McGlothlen.

FOUR-STATE SECTION

A luncheon for the members of the Four-State Section was held at the Engineers' Club of Philadelphia, on Tuesday, October 16, 1923.

An informal meeting of the Section was held following the luncheon, after which those present, through the courtesy of the Engineers' Club of Philadelphia, were given the privilege of attending a large meeting at which the question of "Pollution of Streams" was discussed by many prominent engineers and water works men.

This was the first meeting of the Four-State Section since 1920, and a large number of the members were in attendance.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12, refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Second Annual Report, Ohio Conference on Water Purification, 1922. 1923; 152 pp. **Tastes and Odors from Industrial Wastes Containing Phenol.** Use of chlorine has been omitted at those plants where chlorine application constitutes true factor of safety (Cincinnati, Portsmouth, Ironton, Steubenville). Other plants have decreased the amount of chlorine used (Lorain, Cleveland); or omitted chlorination, substituting excess lime treatment (Marietta, Youngstown); or a combination of both (Bellaire, East Liverpool). **Load Factors.** 20° and 37° bacterial counts were equally favored as routine plant control methods. It was decided that either temperature could be employed and that State Dept. of Health would not expect reports to be made, as a routine, on both. Conference was emphatically in favor of relying on presumptive B. coli test for routine plant control, percentage removals being almost identical with those calculated from confirmed B. coli indices. Chlorination should be applied to filter effluent as a true factor of safety and present U. S. P. H. S. standard, of 2 B. coli per 100 cc. as a maximum, was reasonable, and should be attained. Bacterial load of purification processes was discussed, and an effective size of 0.35–45 mm. for filter sand for Ohio conditions was endorsed. **Analysis.** Consensus of opinion was, that determination of H-ion concentration has no practical significance in water purification plant control in Ohio region, excepting at Akron, where, with soft colored water, it is believed that use of acid alum, to adjust pH from 7.6 to optimum of 6.2, would result in more economical and satisfactory coagulation. **Report of Akron.** J. S. Gettrust. 38–56. Interesting data on operation of Akron plant: efficiencies of different steps in process, as measured by bacterial counts at 20° and 37°C., and by B. coli tests: effect of size of sand, and of bacterial burden: and experiments on pH control, are presented: together with summaries of results for 1916–22 inclusive. Tests on filters with various effective sizes of sand demonstrated marked effect of finer sand in shortening period of service. It is considered that it would be a hardship for some plants to have to meet the U. S. P. H. S. standard with filter effluent, and it is suggested that plants dealing with difficult waters be permitted to chlorinate applied water, using only sufficient coagulant to produce a clear sparkling effluent. **A Study of Percentage Removals at the Cincinnati Plant.** Clarence Bahlman. 57–65. Percentage removals at Cincinnati Plant during 1919–22 are summarized and discussed. Bacterial efficiencies (20°C.) are usually higher than B. coli removals for sedi-

mentation and coagulation; but, for filtration and disinfection, B. coli efficiencies are the higher. In sharp contrast with sedimentation and coagulation, higher bacterial removals are obtained from the filters when water applied is of low bacterial count. Low temperatures tend to reduce removal of turbidity and bacteria by coagulation; highest efficiencies by filtration are obtained from May to September when microscopic organisms are most prevalent. Multiplication lowers bacterial and B. coli removals by coagulation in warm weather, such multiplication occurring only at times of low turbidity. Chlorinated water invariably shows higher counts than filter effluent during summer; but temperature seems to have no effect on B. coli removals by chlorination. **The Relationship between Gas-formers and Confirmed B. coli at the Cincinnati Filtration Plant.** Clarence Bahlman. 66–70. Over 85 per cent of lactose-fermenters in water at Cincinnati Plant confirm to reactions of B. coli. Percentage of presumptive tests which confirm average 88–90 for all waters except chlorinated water, in which confirmations average only 84 per cent. **Relation between Bacterial Load and Quality of Effluent at the Cincinnati Filtration Plant.** Clarence Bahlman. 71–3. Cincinnati plant, for several years, has been operated to produce filter effluent which will, as near as possible, meet Treasury Dept. Standard. This policy has resulted in material improvement in quality of effluent, without unwarranted increase in operating costs. Following have been found to be maximum B. coli contents per 100 cc., consistent with production of such an effluent: raw water, 1100; settled water, 225; applied water, 50. **Discussion of Questions Involving Study of Load Factors as Applied to the Cincinnati Filtration Plant.** Clarence Bahlman. 74–7. Load factors and methods of measuring efficiencies are discussed, and data on filters at Cincinnati Plant are given. Measurement of efficiencies by 20° count is more useful than by 37° count, as there is greater difference between number of bacteria in effluent and in chlorinated water by former method. **A Study of Load Factors on the Division Ave. Filtration Plant at Cleveland, Ohio.** J. W. Ellms and W. C. Lawrence. 78–97. Laboratory results for 1921–22 are given, from which it is concluded that raw water supply is not yet sufficiently polluted to overburden a well operated filter plant. To obtain highest percentage bacterial reductions in water such as that of Great Lakes, it is necessary to use much larger amounts of chemical coagulants than are required to effect clarification; and it seems justifiable to rely, to certain extent, on disinfection. It has been observed that in most cases bacterial content (including B. coli) of disinfected filtered water is lower than that calculated from Streeter's formula. **A Discussion of the Merits of Recently Developed Tests for Small Amounts of Phenolic Compounds Sometimes Found in Public Drinking Water Supplies.** J. W. Ellms, L. A. Marshall and Wendell Phillips. 98–101. The phosphotungstic-phosphomolybdic acid and azo dye tests for phenols are not sufficiently specific for use in examination of natural water supplies. The only specific test is chlorine taste test suggested by Ellms (This J: 9: 463, 1922). There is as yet no satisfactory quantitative test. **An Investigation of the Effect of Resanding with Fine Sand Certain of the Large Filters of the Division Ave. Filtration Plant, Cleveland, Ohio.** J. W. Ellms. 102–9. Experiments with fine filter sand, 0.30 mm. effective size, as compared with 0.49 mm. now in use, have indicated that efficiency is not materially

greater with fine sand, while period of service is reduced 50–65 per cent and percentage wash water increased 100–200 per cent. **Effect of Chlorination of Raw Water Prior to Filtration, at the Division Ave. Filtration Plant, Cleveland, Ohio.** J. W. Ellms. 110–3. Concluded from data obtained from 4-week test period of prechlorination, that such treatment is ineffective, if residual chlorine remains in water applied to filters. Free chlorine attacks colloidal coating on sand grains and destroys ability of filter to remove bacteria in applied water, or hold those contained within the bed. Subsequent application of large amounts of alum does not immediately rectify this condition. **Studies on the Effect of Hydrogen Ion Concentration Adjustments on the Coagulation, Sedimentation, and Filtration of Lake Erie Water using Sulfate of Alumina as the Coagulant.** J. W. Ellms and L. A. Marshall. 114–29. Interesting data on variations in pH of Lake Erie water, due to natural causes and to addition of coagulants, and observations on effect of such variations on operation of an experimental filter plant, are given. Experiments indicated optimum, or isolectric point, for alum treatment of lake water to be pH 7.0–7.1. Amount of alum necessary to adjust to this value is considerably in excess of that required to effect clarification, and entails expense not warranted by results obtained; hence pH control of little value in purifying Lake Erie water. The pH value may vary widely without affecting physical properties of precipitated alumina, such as, ability to flocculate and settle, and effect in clogging filters; rate of precipitation more directly related to quantity of alum applied than to H-ion concentration of water under treatment. Increase in pH above isoelectric point gave increasing quantities of residual alumina as indicated by haematoxylin test, although complete precipitation was not obtained at values below 7. The haematoxylon test for alumina was observed to be more delicate in lake water at pH 8.1, than in distilled water at pH 6.1; 0.002 p.p.m. being detected in the former, and 0.1 in the latter. Residual alumina, reactive to haematoxylin and alizarin S, is present in filtered water from Division Ave. Plant in quantities of 0.1–0.4 p.p.m. **A Comparison between Hardness as Determined by Incrustants plus Alkalinity and Hardness Computed from Calcium and Magnesium Determined Volumetrically.** C. P. Hoover. 130-1. Total hardness of 756 samples of water, determined as incrustants plus alkalinity, compared as follows with results obtained by calculation from calcium and magnesium content, as determined volumetrically:

	RIVER WATER	FILTERED WATER
Incrustants plus alkalinity	254	96
Calculated	257	97

The method is accurate for routine purposes provided that, (1) 50 per cent excess of soda reagent is used, and (2) softened water does not contain excess lime or soda-ash. **Graphic Scheme for Expressing Results of Water Analyses.** C. P. Hoover. 132. Graphic scheme of W. D. Collins, for expressing results of water analyses, described. Quantity of each radical, as shown in analysis, is divided by its respective equivalent combining weight, and figures thus ob-

tained, plotted, anions against cations. **Carbon Dioxide Treatment of Lime Softened Water at Defiance, Ohio.** H. T. Campion. 133–5. Carbonation process in use at Defiance is described. After 15 months' operation, sand appears to be unchanged as regards deposits; effective size has increased, from 0.43 to 0.48 mm., and uniformity coefficient decreased, from 1.50 to 1.27. Practice has been to keep free carbon dioxide at 3 p.p.m., or slightly above neutrality to phenolphthalein. When this figure exceeded, increase in methyl orange alkalinity occurs. Quantity of coke burned, per million gallons water treated, during 1922, averaged 170 pounds, which is abnormally high. **Experience with Double Coagulation at Portsmouth, Ohio.** F. E. Sheehan. 136–8. Advantages of double coagulation, as evidenced at Portsmouth, are: less coagulant required, to obtain equal or higher degree of physical and bacteriological purification; character of floc improved; wash water required almost 50 per cent less; and operation of plant facilitated. Average turbidity in influent to filters averages less than 35, and B. coli less than 100 per 100 cc. An effluent of satisfactory quality prior to chlorination is readily obtained under these conditions. **A Comparison of the Performances of Individual Filters at the Lima Water Purification Plant.** E. E. Smith, 2nd. 139–40. Details on filters at Lima are given. Study of figures recorded shows that filters with finer sand (0.37, compared with 0.43 mm.) require one-half minute longer to pass same quantity of wash water; have consistently higher loss-of-head; have shorter periods of service (about 20 per cent less); and require higher percentage of wash water. **A Comparison of the Four Principal Methods of Water Purification Control.** J. Sheldon Scott. 141–4. An investigation of relative values of principal means of bacteriological control—20° and 37° counts; presumptive and confirmed B. coli indices—was carried out over test period of 8 months, at Steubenville plant. Results are expressed graphically. Standard methods were employed, except that eosine—methylene blue agar was substituted for Endo's medium, for following reasons; uniformity, superior keeping qualities, and ease and accuracy of differentiation of colonies. In every case, point of lowest efficiency in count curve is point of highest efficiency in B. coli curve; indicating that removal of B. coli in the filter remains unaffected by conditions which result in low efficiencies, as measured by bacterial counts. Results are summarized as follows: (1) For control purposes, 20° counts are preferable to 37°. (2) Little choice between bacterial counts and B. coli tests for control of sedimentation and coagulation. (3) Bacterial counts preferable to B. coli tests for control of filtration. (4) Efficiencies as calculated from presumptive and confirmed B. coli indices respectively, are almost identical. **Phenol Tests by the Folin-Denis Reagent on Raw and Treated Mahoning River Water at the Youngstown Filtration Plant.** W. I. Van Arnum. 145–6. Phenol tests on raw and treated Mahoning River water with Folin-Denis reagent are tabulated. It was found desirable to make three 100 cc. distillations from each 500 cc. sample, owing to more intense color produced in first distillate. True phenol solutions showed no such concentration; indicating that part of coloration is due to substances other than phenol; possibly to hydrogen sulfide, which produces a marked coloration with the reagent, and is always present in the slag with which river is contaminated. Following conclusions are drawn from the investigation: (1) Decided diminution in phenol test

color developing in water after excess lime treatment. (2) Increase in phenol tastes and odors attends increased flow of slag in river. (3) Folin-Denis test is not specific for phenols. **Iron Romoval Practice in Ohio.** A. Elliot Kimberly. 147–51. There are 17 iron removal plants at present in operation in Ohio; principal ones being located at Garrettsville, Shelby, Lodi, Wadsworth, Xenia, Leroy and Barberton. Operation at these plants discussed and some results tabulated, which indicate that Darapsky's law, that the aerated water must be subjected to catalytic action of previously precipitated iron sludge, is correct, as applied to ground waters of Ohio; and, that roughing filters, and not coagulation basins, should precede finishing sand filters. Nozzles are preferred to aerators of splash type, as resulting aeration is more thorough, and removal of dissolved gases, more complete.—*R. E. Thompson.*

Water Treatment. Brunner Mond & Co., Ltd., Northwich (Eng.), 1923, 32 pp. Useful booklet, produced in exceptionally pleasing style, dealing with hardness; includes general discussion; descriptions of lime—soda ash and caustic soda—soda ash methods of softening; and methods of treatment of acid water and of water containing sodium bicarbonate, or oil. Medium hard water can be softened to 3 degrees hardness by lime—soda ash method at cost of 2–4 cents per 1000 gallons.—*R. E. Thompson.*

Tunnel for Water Mains under Cemeteries. G. H. Fenkell. Eng. News-Record, **90:** 1054, 1923. An 8.5 feet circular 4-ring brick tunnel 2200 feet long, carries 48 inch hammer-welded steel main under two cemeteries in Detroit, Mich. Depth at one end is 43 feet and at the other 57 feet. Pipe is laid on steel I-beams spaced on 5 feet centers. Single bump riveted joints used on circular seams. Manholes placed at 700 feet intervals.—*Frank Bachmann.*

Coal Consumption Records Used at Philadelphia Water-works. H. R. Cady. Eng. News-Record, **90:** 1054–5, 1923. The method of checking coal cunsumption in connection with traveling stokers consists of counter attached to driving shaft of each stoker, counter readings being multiplied by a factor to take into account travel of grate per revolution of shaft, width of stoker, weight of coal per cubic foot, and fire thickness. These factors are constant, except the last two, for any particular stoker; factor of weight per cubic foot varies with character of coal. Constant can be determined by weighing coal fed to stoker hopper, and reading counter and fire depth; or, by calculating volume of coal passing into furnace per turn of driving shaft, and determining weight of coal per cubic foot.—*Frank Bachmann.*

Sewage Effluent as Boiler Feed Water. Anon. Eng. News-Record **90:** 1049, 1923. If water soft, clarified effluent from septic tank may be used without treatment. Hard water effluent should be treated with lime and soda to soften, and remove organic matter.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Economics of Railway Water-Supply Systems Reviewed. C. H. Koyl. Eng. News-Record, **90:** 1091, 1923. Water softening on Great Northern

Railway estimated to save $1000 per mile of road per year where there is an average of 10 trains per day. On El Paso & Southwestern Railway, this saving estimated at $2700 per mile. Water-treating plants may repay more than their initial cost in a few weeks by release of engines and by increasing speed and service value of cars.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Water Supply and Irrigation Works, Wichita Falls, Tex. A. S. Fry. Eng. News-Record, **90**: 1080–1, 1923. Large hydraulic-fill storage dam, smaller diversion dam 15 miles downstream, and system of main and lateral canals are under construction to furnish water supply for Wichita Falls and to irrigate 110,000 acres. Cost of project estimated at $4,500,000.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Second Water Purification Plant for Dallas, Texas. David Morley, Jr. Eng. News-Record, **90**: 1042–4, 1923. City has three sources of supply: artesian wells, Trinity river, which is filtered, and White Rock reservoir, which is filtered in new plant. New purification plant is designed for 15 m.g.d. Consists of low-lift pumping station, aerator, mixing channel, two sedimentation basins, secondary coagulant basin, 12 rapid sand filters, filtered-water reservoir, and wash tank. Aerator is of concrete, 90 feet long, 14 feet wide and 7 feet deep. Water falls over 8 steps, 86 feet long, so arranged as to give cascading effect, which removes tastes and odors. $CuSO_4$ is used at times in reservoir to destroy algae. From aerators, water passes through 700 feet of mixing channels; is settled in 2 basins, each 300 feet long by 75 feet wide and 16 feet deep; then to secondary basin, 74.5 feet long by 24 feet wide and 13 feet deep; and finally to filters. Lime and $FeSO_2$ are used as primary coagulants, and alum in secondary settling basin. Filters are designed for 2 gallons per square foot of filter area per minute. Plant costs $420,000.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Underground Contamination of the Bad Axe, Mich., Water Supply. W. C. Hirn. Eng. News-Record, **91**: 138–9, 1923. Pollution entered through unused well, 430 feet from used well, through fissures opened by dynamiting, several years ago. Epidemic of intestinal disorders developed, which affected 75 per cent of 2200 population.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Experiments in Water Coagulation with Aluminum Sulphate. F. E. Daniels. Eng. News-Record, **91**: 93, 1923. With $Al_2(SO_4)_3$ and Na_2CO_3, maximum precipitation occurred between H-ion concentration limits of pH 6.0 and pH 7.0. In solutions more alkaline than pH 6.8, dissolution of $Al(OH)_3$ began, and continued with increasing alkalinity, until entire floc was redissolved at pH 10.5. Ca aluminates are less soluble than Na aluminates; dissolution did not begin so soon with precipitation formed from $Ca(OH)_2$, as with that formed from Na_2CO_3.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

High Yield from Small Watershed with Large Water Area. F. I. Winslow. Eng. News-Record, **91**: 64, 1923. A larger yield than normal from watersheds in eastern New England is found at Framingham, in Farm Pond. Increased

yield is attributed to possible underground flow to pond from slightly higher watershed.—*Frank Bachmann.*

Comparison of Cost of Purchasing and Installing Meters and of Additional Water Supply—Parts I and II. Nicholas S. Hill, Jr. Amer. City, 29: 8–11, 1923; 29: 158–161, 1923. Lucid and strong arguments presented for selling water by meter, as contrasted with other methods of charging. Accompanying tables give data as to extent of metering of cities and towns of 25,000 population and over; also reduction in consumption by use of meter. Effect of metering on capital expenditures, on public health and on general efficiency of operation are discussed. Underlying principles of water charges are set forth and analyzed.—*W. Donaldson.*

The Function of Alum in Water Purification. W. F. Donohoe. Amer. City, 29: 32–3, 1923. Brief popular statement.—*W. Donaldson.*

New York City Searches Diligently for Water Waste. William W. Brush. Amer. City, 29: 42–3, 1923. Describes personnel and methods employed by the Department in routine detection and stopping of underground leaks. In eleven years of such effort, since 1910, number of leaks located and repaired was 1523; total leakage stopped amounted to 111 m.g.d., while cost per million gallons saved varied from $1.15 to $3.83.—*W. Donaldson.*

The Waste of City Water by Defective Fixtures. Anon. Amer. City, 29: 123, 1923. Bulletin of Philadelphia Housing Association states that two months' inspection of 2335 premises in midwinter showed 105 leaky fixtures, wasting 5.3 mg.d. Eight leaky fire plugs wasted 1.7 m.g.d.—*W. Donaldson.*

A Jet Booster for an Old Water Supply. J. E. Tupper. Amer. City, 29: 142, 1923. At Pomeroy, Wash., in order to augment discharge through existing 10 inch gravity line, from reservoir, a 2 inch jet device was installed, operating from auxilliary supply at higher elevation. Additional head of 22 feet was gained.—*W. Donaldson.*

Improvoments in the Water Supply of Woodstock, Ill. Kendall Austin. Amer. City, 29: 163, 1923. Woodstock, with daily consumption 720,000 gallons, has replaced former supply works, consisting of 5 wells, 100 to 2000 feet deep, equipped with air-lift and plunger pumps, by two Layne and Bowler wells 196 feet deep, equipped with motor-driven centrifugal deep well pumps. Saving of $46,000 per annum in cost of pumping is claimed.—*W. Donaldson.*

Metropolitan Water Board (London, Eng.) 17th. Annual Report. Can. Engineer, 45: 8, August 21, 1923. During year ending March 1922, Board supplied 91,119.9 million imperial gallons to consumers. Daily average consumption 247.72 million gallons: 36.27 gallons per capita. Latter figure shows average decrease of 3.88 gallons, compared with figures of preceding year. Total estimated population supplied by Board was 6,861,449, representing increase of 57,885 during year.—*N. J. Howard.*

Report of Committee on Water Works and Water Supply. Geo. W. Fuller, Chairman. Proc. Amer. Soc. Municipal Improvements, 1922 Convention: 261–263. Report records a few points of interest in water works construction and operation.—*John R. Baylis.*

The Cleveland Water Supply. A. V. Ruggles. Proc. Amer. Soc. Municipal Improvements, 1922, Convention: 264–268. Briefly describes the Cleveland, Ohio, water supply.—*John R. Baylis.*

Water Supply of Cities: General and Fundamental Principles. Dabney H. Maury. Jour. Western Society of Engineers, **28**: 4, 111, April, 1923. Denver, Norfolk, Tulsa and Army water supply problems discussed. $7,300,000 bond issue to improve Denver's piecemeal constructed system. First unit filter plant capacity 64,000,000 g.p.d. on rate 150,000,000 gallons per acre per day. Plant can be increased to 192,000,000 gallons per day. Lake Prince project to increase Norfolk supply. Comparison cast-iron, wood-stave and concrete pipe. Bond issue representing $90 per capita to give Tulsa suitable water supply. Spavinaw Creek, 60 miles away with dry weather flow 17,000,000 g.p.d. to supply city. Army waterworks cost $11 per capita compared with $55 cost in average city (1917). In United States and possessions with 4,000,000 troops and 2,000,000 civilians not one case of typhoid or other water-borne disease charged to impurity of supply. Organization and operation of Construction Division.—*A. W. Blohm.*

The Distribution and Therapeutics of Iodine. A. Judson Quimby. American Medicine, **18**: 4, 223, April, 1923. Selection of water supplies with regard to iodine content, addition of iodine-bearing mineral waters to existing supplies suggested to compensate for deficiencies. Review of theories concerning physiological action of iodine.—*A. W. Blohm.*

Final Report of the Water Power Resources Committee. Board of Trade, London, England, 1921. Committee appointed 1918 to examine and report on water resources of United Kingdom, availability for industrial purposes, conservation and systematic utilization. Water commission recommended to compile records, allocate water resources, adjust conflicting interests, control uses, group watersheds, develop rivers, improve law relating to surface and underground waters. Maps, tabulations, estimated cost of development.—*A. W. Blohm.*

Some Hints on General Water Works Maintenance. Sequel to "A progressive Water Works and Its Methods" (This J., **10**: 1145). Fire & Water Eng. (5) **A Brief Summary of the East Bay Water Co's. Plant, as of October, 1922.** P. E. Magerstadt. **73**: 677, April 18, 1923. Company operates in territory about 35 miles long; averaging from 2½ to 5 miles wide. It serves cities of Oakland, Berkeley, Alameda, Richmond, Piedmont, Albany, Emeryville, El Cerrito, San Leandro, and Newark. Population served is approximately 350,000. Some idea of size and activities may be gained from following facts: employees number 505; motor vehicles maintained, 83; volume of water filtered

during past 12 months, 5.169 billion gallons; watershed land owned, 42,000 acres; storage reservoirs, 3; with total capacity of over 19 billion gallons; distribution reservoirs, 39; with total capacity of 286 million gallons; transmission mains, 91 miles; distribution mains, 1146 miles; active services, 86,477; services gained during last 12 months, 5726; meters in ground, 83,137; hydrants, 2844; average daily consumption during past 12 months, 23.1 million gallons; pumping plants, 3 steam driven and 27 electrically driven. (6) **Construction.** L. L. FARRELL. **73**: 678, April 18, 1923. All orders and instructions pertaining to construction and maintenance are passed through official channels to Corporation Yard Office. Concrete meter boxes and covers are used; manufactured by local companies. 2- and 3-inch mains are generally of wrought iron; 4 to 12-inch, of cast-iron; 12-inch, and larger, of sheet iron, about 30 feet long. 2-inch cast-iron pipe has been used recently with gratifying results; it is less susceptible to chemical action of soil and cement joints may be used to eliminate electrolytic action; comes in 5 feet lengths; made by McWane Foundries. Smaller mains are laid from 18 inch to 2½ feet deep; larger, from 3 to to 6 feet deep. Cement now used almost exclusively as joint filler, both on sheet and on c.-i. pipe. Practically every main has insulated joint every 100 feet; cement used for c.-i., and, for sheet iron mains, special flanged unions with fiber gasket, fiber tube over body of bolt, and fiber washers under bolt head and under nut. Services are also insulated wherever possible, both at main and on house side of meter. Oxy-acetylene welded joints have been tried out on 12-, 16-, and 20-inch lines, carrying 200 pounds pressure; they are not only more substantial than either lead bands, or rivets, but also much more economical. Services, up to, and including, 2-inch, are connected to main with lead service connection. All service taps, up to, and including, 6-inch, are made with pressure on main. All gate valves, and practically all hydrants, are installed at street intersections. Use of tractors and plows for actual breaking up of semi-permanent pavement, and also for general trench work in almost any kind of soil, has proven a decided success.—*Geo. C. Bunker.*

Putting the Water Works on a Self-Sustaining Basis. V. BERNARD SIEMS. Fire & Water Eng., **73**: 417, March 7, 1923. Taking Water Department of Greater Baltimore as example there are given salient features of plan for obtaining revenues to take care of operating and maintenance expenses, sinking funds, interest on various bond issues, and small surplus to be used for any necessary extensions; or, in other words, to render this utility self-supporting. —*Geo. C. Bunker.*

Tools That Make the Water Works Man's Job Easier. ALEXANDER MILNE. Fire & Water Eng., **73**: 455, March 14, 1923. Brief notes on following devices: wireless pipe locator; magnetic dipping needle; electric leak locator; electric thawing apparatus; pipe pushing jacks; tapping machines; portable meter tester; portable air compressor; and trenching machines.—*Geo. C. Bunker.*

How to Prevent Spontaneous Combustion in Coal Piles. O. P. HOOD. Fire & Water Eng., **73**: 495, March 21, 1923. Practical suggestions for fire and water works departments. Illus.—*Geo. C. Bunker.*

Water Company Inaugurates Weekly Advertising Campaign. Fire & Water Eng., 73: 501, March 21, 1923. Davenport, Iowa, Water Company is publishing series of 25 weekly advertisements in local dailies, in order to make their methods and practices known to public and to their consumers.—*Geo. C. Bunker.*

Fixing the Value of Fire Protection Service. Caleb Mills Saville. Fire & Water Eng., 73: 535, March 28, 1923. Public Utilities Commisssion of Connecticut recently rendered decisions whereby Ansonia Water Co. and Bridgeport Hydraulic Co. are permitted to make charges for that portion of their capital invested in excess construction of plant necessitated by fire protection service. In case of former company, municipality was ordered to make annual payment of $10, per hydrant in service, and inch-foot charge of $0.009; in latter case, municipality was ordered to pay $150,000 per year to company for fire protection service, on basis of 1.2 cents per inch-foot of mains. In this State, annual reports must be submitted to Commission by municipalities owning or operating utilities for public service.—*Geo. C. Bunker.*

Rapid Filter with Automatic Wash Gear. F. Johnstone-Taylor (England). Fire & Water Eng., 73: 589, April 4, 1923. Brief illustrated description of continuous washing, or drifting sand, filter. Operating head of about 30 feet is necessary; filtering rate of 140 gallons (British) per square foot of bed area per hour can be worked to.—*Geo. C. Bunker.*

Water Softening Can Be Accomplished at Small Cost. Charles P. Hoover. Fire & Water Eng., 73: 623, April 11, 1923. Instructive paper, well illustrated by diagrams, on water softening processes, based upon operation of Columbus, Ohio, Plant. Tables showing cost of operating and maintaining Water Softening and Purification Plant for years 1909 to 1922, inclusive, and cost of chemicals, are given. Influence of temperature, time, mass action, and addition of alum are discussed. At Columbus Plant lime, soda-ash, and alum are all added at practically same point; all of alum is now added to raw water as it enters plant. Here and at new Newark, Ohio, plant, all of chemicals required to soften water are added to approximately 25 per cent of water, which is subsequently mixed with the 75 per cent undosed portion of supply. This overtreatment results in quick formation of large flocs and crystalline precipitates. Carbonation of water to prevent deposits of carbonates in distribution system, meters, and hot water systems is discussed. Experiments with phosphoric acid have been dropped. Principal conclusions are: (1) It is necessary to get precipitates into flocculent crystalline condition, so that they will settle out almost instantly. (2) It is necessary to provide settling basins only sufficiently large to retain sludge, say 5 hours, at Columbus; or, perhaps, a Dorr Thickener, from which sludge is removed continuously, would be sufficient. More definite data can be given on this process after results of operation of thickeners at Highland Park, Ill., and Newark, Ohio, are available. (3) After sludge has been separated from water, in order to produce stability, carbonation with CO_2 gas should follow; or, normal carbonates may be converted to bicarbonates by acid treatment.—*Geo. C. Bunker.*

How to Stop the Contractor from Wasting Water. William Luscombe. Fire & Water Eng., 73: 673, April 18, 1923. Percentage of water sold contractors, in Gary, Ind., during building season months, if figured at regular meter rates, ranges from 3 to 8 per cent of total. In great majority of cases, water is furnished on flat rate basis, and during warmer months, when construction work is carried on in general way throughout city, water wasted is relatively large, and, by investigation, is believed sometimes to exceed all legitimate uses many times. Each party is cautioned in friendly, but firm, way, against wasting water, and for third offense, supply is discontinued, and not turned on again until assurance is given that privilege will not be abused, and payment of $1.00 made. In cases of frequent and flagrant violations offender will be required to provide suitable place for meter, and water will be furnished only at regular meter rates. Meters are not generally installed on account of high cost due to local conditions.—*Geo. C. Bunker.*

How Much Does a Consumer Really Require? Abel Wolman. Fire & Water Eng., 73: 815, May 9, 1923. In discussion on possibility of reducing per capita consumption of water in Baltimore, Md., without detriment to individual or public health, following differences in demands for water are brought out: *subsistence demand*—that required for proper functioning of human mechanism—is set at 1½ gallons per person per day; *sanitary demand*—that covering usage for bathing, washing of clothes, toilet equipment, and minor necessary household uses—varies between 10 and 20 gallons per person per day; sum of subsistence and sanitary demands ranges from 15 to 25 gallons per day; but, allowing for a factor of safety, *maximum rational water requirement* may be set at 30 gallons per person per day for domestic purposes; however, in the United States, in most instances consumption is above this latter figure, and usually above 50 gallons, which is designated as *maximum reasonable use.* Daily per capita consumption in London is less than 50 gallons and average for principal towns in Great Britain is 42 gallons, as compared with 142 gallons in Baltimore. Requirements of human mechanism for water for continuance of life and for proper environmental sanitation are relatively low. In only few instances, do such requirements control actual per capita consumption in a community. Beyond a consumption of 50 gallons per person per day, irrational use of water begins; in this region curtailment may be made without damage to health. Correlation of water and disease, in bulk of cases, lies in factor of quality, and not that of quantity, of water consumed.—*Geo. C. Bunker.*

Regulations Concerning Water for Drinking and Culinary Purposes on Vessels Navigating on the Great Lakes and Inland Waters. Dept. of Health, Canada. 6 pp., 1923. Regulations approved by Order in Council on 19th June 1923. Water furnished is required to contain not more than 2 B. coli group organisms per 100 cc., determined according to A. P. H. A. standard methods (Phelps' calculation). List of prescribed areas where water shall not be obtained overboard without knowledge and consent of the department, is included.—*R. E. Thompson.* (*Courtesy Chemical Abst.*)

Effect of Meters on Water Consumption. D. H. Maury. Western Soc. Engr.; Eng. Contrg., 59: 1087, 1923. Table and diagram summarize data.—*Langdon Pearse.*

Construction and Operation of Warren, Ohio, Water Filtration Plant. S. N. Vance, P. J. O'Connor. Mun. Cty. Eng., 64: 183–8, 1923. Rapid filter plant; cost $201,270.57; has capacity of 6 m.g.d.; divided into 6 units. Provision is made for dry feed of alum amd lime. Mahoning R. water is treated by 3½ hour coagulation. Laboratory is provided.—*Langdon Pearse.* (*Courtesty Chem. Abst.*)

Features of New Well Supply at Memphis, Tenn. J. R. McClintock. Mun. Cty. Eng., 64: 47–51, 1923. Well water development to serve 175,000 people with 18 m.g.d. Water contains 110 p.p.m. free CO_2. Air lift pumping is used, air supply being metered. Coke aerator trays are supplied in series of 4 superimposed; followed by rapid sand filters.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

,Charleston (S. C.) Water Treatment Notes. J. E. Gibson. Pub. Works, 54: 284–5, 1923. Use of hydrated lime and of caustic soda for softening filtered water (hardness 20 to 25 p.p.m.) is described, the soda treatment requiring about ⅔ grain of 76 per cent caustic soda per gallon as against 1¼ grain hydrated lime. Cost is increased $16.00 per day, for 6 million gallons—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Chlorine Production at Independence, Mo. A. H. Gallagher. Pub. Works, 54: 336–7, 1923. An electrolytic cell produced Cl for a period of 222 days at 4.81 cents per pound for Cl, with current at 1.7 cents per kilowatt hour. Operation is said to be simple, result good.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

A $4,500,000 Texas Water Supply Project. R. A. Thompson. Eng. Contrg., 60: 277–80, 1923; Pub. Works, 54: 158, 1923. Hydraulic fill dam; 100 feet high, 7500 feet long; built for Wichita Falls. Spillways are of masonry.—*Langdon Pearse.*

Cost of Supplying Water at Columbus, Ohio. C. P. Hoover. 1922 Ann. Rept., Supt. W. W.; Eng. Contrg., 59: 1064, 1923. Total cost was $120.70 per million gallon. Average selling price was $160 per million gallon.—*Langdon Pearse.*

Portland Cement Joints for Force Mains. William Wheeler. N. E. W. W. Assn., 1923; Eng. Contrg., 59: 1047–9, 1923. Methods and costs are described with tests of leakage.—*Langdon Pearse.*

Pump House and Intake Pipe Line Connection. Contract Record, Eng. Contrg., 59: 1038–40, 1923. Describes river intake for water supply at Three Rivers, Que., for new paper mill, 36 inch pipe was laid 650 feet from shore.—*Langdon Pearse.*

Cost of Construction of 48-inch Water Main at New Bedford, Mass. S. H. Taylor. Ann. Rept. Water Bd., 1922; Eng. Contrg., 59: 1060, 1923. Cost with pipe at $46.50 per ton and specials at $130.00 per ton on 18,813 feet averaged $25.58 per foot laid; including $4.31 for labor.—*Langdon Pearse.*

An Improved Pitometer. F. W. Greve. Eng. Contrg., 59: 1050–1, 1923. Sketch and table are given.—*Langdon Pearse.*

Some Costs of Lead Substitute in Pipe Joints. V. F. West. N. E. W. W. Assn., 1923; Eng. Co ıtrg., 59: 1051–2, 1923. Comparative cost figures on lead and leadite—show saving from $0.60 on 6-inch to $1.58 on 16-inch.—*Langdon Pearse.*

Present Status of Sanitary Engineering, H. P. Eddy. Am. Soc. C. E., 1923; Eng. Contrg., 59: 1053–8, 1923.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Consumption at New Bedford, Mass. Cost of Cleaning and Testing Meters. S. H. Taylor. Ann. Rept., 1922; Eng. Contrg., 59: 1076, 1083, 1923. Consumption was 79 gallons per capita daily in 1922; of which, domestic 29, manufacturing 32, and leaks and unaccounted, 18 gallons. Cost of cleaning and testing meters is given for 6, 3, ¾, ⅝ inch: being $2.35, $3.90, $2.35 and $2.41 respectively.—*Langdon Pearse.*

Cost of Installing and Changing Meters at Portland, Oregon. Rept. Dept. Pub. Utilities, 1921.; Eng. Contrg. 59: 1083, 1923 Costs were: installing $4,707; changing $0.779; removing $0.589; repairing $2.022. Mostly ⅝ inch. —*Langdon Pearse.*

Effect of Filtration on Typhoid Death Rate at Columbus, Ohio. C. P. Hoover. Ann. Rept. Supt. W. W., 1923; Eng. Contrg., 59: 1058, 1923. Table shows typhoid fever death rate from 1901–1922. After filtration began, average for 8 years 1901–1908 was 54.5 per 100,000; for 14 years 1909–1922, 10.5; with 1.2, in 1922.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Cost of Pumping Water at Columbus, Ohio. C. P. Hoover. Ann. Rept. Supt. W. W., 1922; Eng. Contrg., 59: 1070, 1923. Cost was $18.63 per million gallon.—*Langdon Pearse.*

Cost of Water Main Construction at Pasadena, Cal. S. B. Morris. 9th Ann. Rept. Water Dept.; Eng. Contrg., 59: 1070, 1923. Cost is given, for years 1914 to 1922 inclusive, for 4 and 6 inch cast iron pipe laid.—*Langdon Pearse.*

Cost of Laying Water Mains at Columbus, Ohio. C. P. Hoover. Ann. Rept. Supt. W. W., 1922; Eng. Contrg., 59: 1073, 1923. Cost is given for pipe 4- to 24-inch, showing labor and material.—*Langdon Pearse.*

Private Fire Protection Charges and Metering of Sprinkler System. John Simpson. Pub. Works, 54: 163–5, 1923. Discusses underlying principles.—*Langdon Pearse.*

Groined Arches. P. O. Macqueen. Am. Soc. C. E.; Pub. Works, **54**: 158-9, 1923.—*Langdon Pearse.*

Gasoline Operated Auxiliary Pumps. S. L. Fear. Can. Sect. Am. W. W. Assn., 1923; Eng. Contrg., **59**: 1062, 1923.—*Langdon Pearse.*

Progress on the Wanaque Project. Pub. Works, **54**: 149–153, 191–4, 1923. Complete description given of progress and construction methods on concrete dam and 25 miles of aqueduct including tunnels. Machine mucking is described as well as unusual features in sheet piling and dewatering.—*Langdon Pearse.*

Wear Tests of Concrete. D. A. Abrams, et al. Proc. Am. Soc. Testing Materials, 21, 1013–38, 1921. From Chem. Abst., **16**: 1645, May 20, 1922. Eleven investigations carried out at Structural Materials Research Laboratory over a period of 6 years are outlined. Factors which gave concrete of high strength also gave concrete of high resistance to wear; increasing quantity of mixing water beyond minimum required to produce plastic caused material increase in wear; curing under favorable conditions exerted a marked influence in reducing wear; wear reduced by longer mixing and by increase in age.—*R. E. Thompson.*

A Proposed Method of Estimating the Density and Strength of Concrete and of Proportioning the Materials by the Experimental and Analytical Consideration of the Voids in Mortar and Concrete. A. N. Talbot, et al. Proc. Am. Soc. Testing Materials, 21, 940–75, 1921. From Chem. Abst., **16**: 1645, May 20,1922. Relation between voids and strength of concrete. Method outlined for estimating strength and density of concrete of different proportions by determining voids in mortar only. Applied to estimating proportions necessary for obtaining given strength and density. Two appendices give technique of mortar void test and bulk and weight measurement in field.—*R. E. Thompson.*

Relation between Molded and Core Concrete Specimens. H. S. Mattimore. Eng. News Rec., **88**: 73, 1922. From Chem. Abst., **16**: 1645, May 20, 1922. Studies to determine reasons for differences in laboratory and field compressive tests of concrete have resulted in considerable progress in rational design of concrete mixes. Cores cut from concrete in place have higher strength than molded specimens.—*R. E. Thompson.*

The Theory and Practice of Stone-Wood (Magnesia Cement or "Composition") Floorings. A. Stettbacher. Schweiz. Chem. Ztg., 113–7 1921. From Chem. Abst., **16**: 1646, May 20, 1922.—*R. E. Thompson.*

Failure of a Mortared Smoke Stack. Vn. Rev. Mat. constr. trav. pub., **147**: 225, 1921. From Chem. Abst., **16**: 1646, May 20, 1922. Failure of a 54-in. smoke stack which was found to be listing 50 cm. (at the top) in the direction from which heavy winds were always blowing is explained by combination of

sulfur from fuel with the lime of mortar to form gypsum, causing swelling on the side furthest from wind. An analysis of the mortar showed 1–1.5 per cent SO_3 in the half against the wind and 7–12 per cent in the opposite side.—*R. E. Thompson.*

Deterioration of a Gas Plant Chimney. ANON. Business gaz., **46**: 77–8, 1922. From Chem. Abst., **16**: 1654, May 20, 1922. An analysis of the mortar on the inside of the chimney showed that it had been decomposed by sulfuric acid (4.8 per cent present). The mortar was loose, soft and moist, all the carbon dioxide had been eliminated and of the matter insoluble in hydrochloric acid only the silicates remained, principally aluminum silicate. The use of fuels high in sulfur and the cooling of the waste gases below the condensation point of water vapor, resulting in the formation of sulfuric acid, is believed to be responsible.—*R. E. Thompson.*

Destructive Effect of Gas Liquor on Ferro-Concrete. B. HAAS. Chem. Ztg., **46**: 39, 1922. From Chem. Abst., **16**: 1655, May, 20, 1922. Destruction of concrete tanks containing gas liquor probably caused by corrosive action of ammonium salts in liquor on tree lime of concrete. Method of making concrete resistant to this action is described.—*R. E. Thompson.*

The Construction of a Storage Reservoir on the Site of Underground Workings. T. C. GREENFIELD. Surveyor, **63**: 1616, 7–10, Jan 6, 1923,. Construction of a 200 million gallon storage reservoir (Blaen-y-Cwm reservoir) on site of an old coal mine at Beaufort, Breconshire, Wales, described in detail. Construction commenced in the autumn of 1918 and practically all the work below the surface is now completed. Concrete foundations for a dam core wall were carried down to the "Farewell" rock, necessitating the excavation of trenches 60 to 70 feet deep in places. A special punning machine of very simple design operated by an 8 h.p. Petter oil engine was used in the work.—*Rudolph E. Thompson.* (*Courtesy I. W. M.*)

Separation of Bacteria by Filtration with Zsigmondy-Bachmann Membrane Filters. H. MEYERINGH. Z. Hyg. und Infekt-Krankh., **97**: 116–136. 1922. Chem. Zentr., **94**: II, 313, 1923. Jour. Soc. Chem. Ind., April 6, 1923. p. 289A. Zsigmondy-Bachmann filters (cf. G. P. 329, 060 and 329, 117; J., 1921, 203A), if suitably selected, rapidly yield a germ-free liquid, and, moreover, the ease with which the residues are removed from the filters renders them especially suitable for separating bacteria from such liquids as water and urine. Their low absorptive capacity renders them suitable for filtering colloidal solutions. A lower grade of porosity is necessary to prevent propagation of individual species of bacteria through the filters than for simple filtration. By employing filters of low porosity, propagation of bacteria through the filters is entirely prevented, and these can be used with safety for the rapid production of germ-free drinking water, (L. A. C.)—*A. M. Buswell.*

Process for Removing from Water Excess of Oxidising Agents Used in Sterilising the Water. Permutit A. G. G. P. 357, 893, 1.11.13.—Jour. Soc. Chem. Ind.,

42: 14, 289 A, 1923.—Excess of chlorine, hypochlorites, ozone, hydrogen peroxide, and substances such as perborates and percarbonates which yield hydrogen peroxide used in sterilising water, are removed from the water by filtering it through metal oxides which have a catalytic action on, but do not enter into chemical reaction with, the substances in solution. Nickelic, cobaltic, ferric, and cupric oxides, and lead monoxide, or mixtures of these with manganic oxide, are suitable for the purpose, and these are preferably precipitated on porous organic or inorganic material such as base exchanging silicates. (L. A. C.)—*A. M. Buswell.*

The Stream-Line Filter. Prof. J. W. Hinchley. Chem. & Ind., 42: 20, 489, May 18, 1923. A remarkable filter had been invented by Prof. Hele Shaw, F. R. S. whose work on stream-line motion of fluids is so well known, and whose ingenious clutch, steering gear, hydraulic transmission, pipe joints and taps have made his name familiar all over the world. The filter consists of several thousand similar sheets of paper or fabric impervious to the liquid to be treated, and pierced accurately with a large number of equidistant holes. The sheets are placed in a pack so that the holes coincide, and are secured between endplates. By means of channels formed in these endplates alternate rows of holes may be connected together as the inlet for the liquid to be filtered, whilst the other holes connect with other channels in a similar way, forming the exit for the filtrate. True filtration may take place between the sheets through the interspaces formed by the roughness of the paper or fabric. By squeezing the pack, the finest materials, bacteria, colloid particles, etc. may be retained by the filter, and on releasing the pressure it may be readily cleansed by driving a washing liquid in either direction. The formation of a hard cake is not allowed to take place, but the precipitate or residue is removed by allowing the contents of the inlet holes to discharge either intermittently or continuously through a suitable orifice. The filter possesses all the useful properties of a sand or porous pottery filter with the wonderful addition of a means of adjustment of porosity and of cleansing which puts it in a separate class.—*A. M. Buswell.*

Steel High Pressure Line Installed by the City of Ottawa, Ont. R. E. W. Hagarty. Contract Record, 37: 10–1, 1923. 51-inch high pressure main, ¾ mile long, recently completed in Ottawa. Riveted steel pipe chosen as most economical type of construction. After testing to 225 pounds cold water pressure, pipes immersed in coal tar bath (300°F.) for 5 minutes, wrapped with layer of jute hessian cloth, and again treated with tar.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Descriptions of Some Water Works Pumping Plants. P. L. Evans. Contract Record, 36: 1278–9, 1922. Recent installations of Rees Roturbo pumps at Windsor, Guelph, Stratford and Montreal described and illustrated. This type of pump is also being widely used for general industrial purposes, such as boiler feed, etc.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Water Supply of Montreal. Anon. Contract Record, 36: 1269–71. 1922; 37: 7–10, 1923. Review of development of water works system of Montreal. Supply drawn from St. Lawrence River through open aqueduct 40 miles in length.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Early Public Health in Toronto. Robert Wilson. Pub. Health Jour., 14: 210–4, 1923. History of public health legislation in Toronto reviewed. Board of Health dates back to at least 1861 and first Medical Health Officer appointed in 1883. Sanitary conditions of City at that date contrasted with present pure water supply, absence of privy pits, incineration of garbage, etc. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Investigations in the Sanitation of Swimming Pools. A. V. Delaporte. Bull. 8: Division of Sanitary Engineering, Provincial Bd. of Health, Ont.; 40th Annual Rept., 163–74, 1921. Investigation of 4 swimming pools in Ontario. Found that, if residual Cl in the pool water before bathing commenced in excess of 0.2 p.p.m., water would remain practically sterile throughout bathing period. Algal growths successfully treated by applying $CuSO_4$ after bathing over Saturday night, precipitated copper being removed by filtration before bathing commenced Monday. Analysis of water showed that no trace of Cu remained in solution.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Fortieth Annual Report. Provincial Bd. of Health, Ontario, Canada. 1921. 438 pp. In 1910 there were but 8 filtration plants and 1 chlorination plant in Ontario; while in 1921 42 per cent of public water supplies were protected by filtration and over 82 per cent by chlorination. Typhoid death rate of cities in the province reduced from 51.3 to 4.3 per 100,000 during the past 12 years. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Medical Health Officer's Report, 1922. Vancouver, B. C., Canada. F. T. Underhill. 31 pp. Water supply drawn from Capilano River and Seymour Creek. Av. compn., in p.p.m., of Capilano and Seymour waters, respectively, was as follows: total solids, 49.6, 48.3; residue on ignition, 31.6, 31.6; organic residue, 18.0, 16.7; chlorides, 2.77, 2.59; free NH_3, 0.014, 0.013; albuminoid NH_3, 0.028, 0.026; nitrates, 0.71, 0.67; nitrites, none, none; and reaction, neutral, neutral. Only 3 cases of typhoid reported and no fatalities from this disease occurred during year.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Typhoid Fever at Cochrane. J. W. S. McCullough. Pub. Health Jour., 14: 220–2, 1923. Typhoid epidemic at Cochrane, Ont., believed to have been directly caused by pollution of water supply. Supply obtained from springs; Spring Lake, the overflow from the springs, being used as auxiliary supply. During dry season last fall and during the winter quantity of water derived from springs was inadequate, and considerable amount of water drawn from Lake level of which consequently lowered by nearly 6 feet. At time of outbreak level of water nearly 3 feet below that of lower lakes receiving town sewage, and, as result, sewage-contaminated water flowed back and entered intake. During this time blanket of snow and ice effectually concealed from view true

conditions. Chlorinating apparatus has been installed and in operation since that date.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Chemical Control on a Boiler Plant. W. Whitehead. Gas World, **76:** 1967 (Coking sex.), 13–4, 1922; Iron and Coal Trades Review. **104:** 457. From Chem. Abst., **16:** 1854, June 10, 1922. Combustion and flue gas control and water softening discussed.—*R. E. Thompson.*

Graphical Studies of Gas Producer Operation. W. Claus and L. Neussel. Ver. deut. Ing., **65:** 769–73, 1921. From Chem. Abst., **16:** 1856, June 10, 1922. Series of charts showing (a) chemical composition of producer gas, (b) temperature of combustion, and (c) most advantageous operation, were drawn, using as basis ternary diagram suggested by W. Ostwald in his book "Graphics of Combustion Engineering" (cf. C. A. **14:** 2414).—*R. E. Thompson.*

Graphical Treatment of Stack Gas Analysis and of Producer Gas Analysis. W. Trinks. Blast Furnace Steel Plant, **10:** 131–5, 1922. From Chem. Abst., **16:** 1856, June 10, 1922. Review of charts introduced by Ostwald and developed by Claus and Neussel (see preceding abstracts and C. A. **16:** 1144).—*R. E. Thompson.*

Steam Efficiencies. T. W. Harper. Gas World, **76:** 319–21, 1922. From Chem. Abst., **16:** 1857, June 10, 1922. Boilers and accessories, their merits and operation, feed water, scale, solvents, water softening, draft, grate area, superheaters and radiation losses discussed.—*R. E. Thompson.*

Iodine; Rapid Determination of, in Mineral Waters Containing Sulphides. J. Dubief. Ann. Falsif, **16:** 80–82. 1923. Chem. and Ind., **42:** 22, 471 A, June 1, 1923. Sulphides and organic matter are oxidised with alkaline potassium permanganate and halogens then liberated with sulphuric acid, and dissolved in carbon bisulphide. Excess of permanganate is removed with hydrogen peroxide. If weight of bromine present is less than 5 times that of iodine it does not interfere with colorimetric determination of iodine in carbon bisulphide solution, and this is immediately proceeded with. If more than this proportion of bromine is present, bromides of iodine are formed and colour of carbon bisulphide solution becomes yellowish. N/10 potassium thiocyanate solution is then added drop by drop, with agitation, until yellow colour disappears and solution becomes violet again. By this means 0.05 mgm. of potassium iodide can be detected mixed with 2000 times its weight of bromide. Solution should not contain more than 0.5 mgm. of iodine or coloration is too intense for exact determination. The iodine solution must be kept perfectly cool to avoid loss of iodine.—*A. M. Buswell.*

Determination of Carbonate Ion in Mineral Waters Containing Sulphides. F. Touplain and J. Dubief. Ann. Falsif., **16:** 76–80, 1923. Abstracted in Chem. & Ind. **42:** 22, 471 A, June 1, 1923. Direct determination of carbonate ion in mineral waters by evaporation to dryness, liberation of carbon dioxide with sulphuric acid, and subsequent absorption with soda-lime, gives inac-

urate results in presence of sulphides owing to variation of the equilibrium between hydrogen sulphide and carbonic acid, oxidation of sulphur to strong acids, and production of sulphur dioxide, which is weighed as carbon dioxide. Sulphides may be eliminated by agitating the water with a small excess of lead peroxide for about 15 min. and subsequently adding hydrogen peroxide and warming to 45°C. for half an hour. Water is cooled, filtered, and carbon dioxide liberated with a mixture of sulphuric acid (2 vols.) and concentrated potassium bichromate (1 vol.) by which any thiosulphates not completely oxidised are transformed into sulphates and sulphuric acid. Carbon dioxide set free is then free from sulphur dioxide.—*A. M. Buswell.*

Standardization of Analytical Methods for Analysis of Potable Waters in the Belgian Army. Ch. Sillevaerts. Arch. Med. Belg., 75: 753, 1922; Wasser und Abwasser 18: 17. January 13, 1923. Methods for the usual chemical determination. Methods for bacteriological work include counts on meat extract peptone-gelatine; Bact. coli determinations using Vincent's phenol broth at 41°C; the cholera red test in peptone water. Waters are to be grouped into 3 classifications: (1) good; (2) usable after treatment; (3) bad.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Safe Water for Camping Parties. "Radio Health Hints," N. Y. State Bd. Health, Public Health (Michigan), 11: 240, 1923. If possible, carry supply of water from home. Look over source of water supply. Suspicious water should be boiled 5 minutes before use. One well in New York State caused 60 cases of typhoid last year.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Influence of Silt in the Velocity of Water Flowing in Open Channels. A. B. Buckley, Jr. Water and Water Eng., 25: 132, April 20, 1923. Discharge of Nile, obtained by Buckley-Wilson discharge recorder, operated by float stations 5 km. apart and automatically combining surface slope and depth according to Kutter's formula, was too low at times of arrival of silt-containing waters. Error of Kutter's, Bazin's, and Manning's formulae as much as 50 per cent. Introduces a new formula (not stated in article) known as Beleida formula which is said to give very accurate results at such times by introduction of a silt factor. Work on the Nile should be correlated with work done elsewhere.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Calcutta Water Supply. Anon. Water and Water Eng., 25: 140, April 20, 1923. Taken from the River Hooghly and supplied both filtered and unfiltered. Filtered water is taken 12 miles above city and passes through slow sand filters. Capacity of filters will be increased from 35 to 70 m.g.d. (Imperial) and an 8 m.g. service reservoir will be constructed at Tallah.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Durban (So. Africa) Water Supply. Anon. Water and Water Eng., 25: 141, April 20, 1923. Great difficulty with silt has been experienced. The Camperdown reservoir has lost 12,272,000 Imp. gallons capacity since September, 1920. At Umlas works there are 8 slow sand filters cleaned on an average

of once a month. Coedmore works has 6 slow sand filters cleaned on an average of 14 times a year. Six new beds similar to the existing beds, but much larger, are being constructed with total area of 66,378 square feet. Clear water reservoir with earth wall and puddle core has a capacity of 105 m.g. (Imp.). Additional pipe lines are being laid to increase discharge capacity to minimum of 6 m.g.d. Only plant in South Africa to use liquid chlorine. This has given satisfaction.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Apparatus for Chlorinating Water or Other Liquid. W. Patterson. British Patent, 188045; Water and Water Eng., **25**: 147, April 20, 1923. Relates to apparatus of the type in which chlorine flow is measured or calculated by taking difference in pressure on each side of a restricted opening through which the gas passes before admixture with the liquid to be chlorinated. It is therefore to be distinguished from Brit. Pats. 158578 and 166191 in which the flow of chlorine is actually measured by the sealing device itself. The object is to provide isolation of the chlorine-control apparatus from the water or liquid to be chlorinated.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst*).

Waterway Building and Swimming Pools. Max P. Grempe. Deutsche Tiefbau-Zeitung, **22**: 258, 1922; Wasser und Abwasser, **18**: 60, February 10, 1923. When streams are being canalized, swimming pools may be constructed behind the retaining walls and fed by, and emptied into, stream. They do not interfere with shipping as they are not in canalized section. Where pure condenser water available it may be utilized for such heat as it contains.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Contamination of the Sub-Soil as a Result of a Fire. M. Levy. Ann. Hyg. Publ. et Med. Legale, **38**: 284, 1922; Wasser und Abwasser, **18**: 66, March 10, 1923. In June 1917, factory at Grafenstaden, in Alsace-Loraine, burned, and water was pumped into the fire for 24 hours, from the Ill river. Water of shallow wells near by became turbid and had a petroleum taste. The chlorides, oxygen consumed, bacterial count, and Bact. coli content were all raised. After six weeks contamination had subsided.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

St. Louis Tests Three Water-Main Joint Materials. Leland Chivvis. Eng. News-Record, **91**: 190–1, 1923. Tests were made with lead, cement and leadite. Conclusions reached were: Cement and leadite far superior to lead as insulators. Insulating value of these materials not vitiated by water in pipe. Cement and leadite will stand far more deflection than lead, without serious leakage. Lead and leadite joints can be made in any season and under adverse conditions; while cement is under a disadvantage in winter and in wet trenches. Lead and leadite joints permit water to be turned on and line put in service immediately; while cement requires period of preliminary setting. Cement joints are hard to gouge out. Sulphur fumes of leadite might become oppressive in confined working space. St. Louis is planning on laying considerable amount of small pipe with cement joints, and, unless price of lead drops, will try leadite during freezing weather.—*Frank Bachmann.*

NEW BOOKS

Report of the Committee on Sedimentation. THOMAS WAYLAND VAUGHAN, Chairman. Presented at annual meeting of Division of Geology and Geography of National Research Council, April 18, 1923. Issued by National Research Council. Price $1.00. 68 pages mimeographed. Report contains following articles: **Studies in Sedimentation in the University and Colleges in the Eastern Part of the United States.** J. VOLNEY LEWIS. **Studies in Sedimentation in the University and Colleges between the Allegheny Front and the Rocky Mountains.** A. C. TROWBRIDGE. **Studies in Sedimentation by the State Geological Surveys.** J. A. UDDEN. **Investigations of Sediments by Federal Institutions and the Carnegie Institution of Washington.** THOMAS WAYLAND VAUGHAN. **Chemical and Physical Researches on Sediments.** H. E. MERWIN. **Color Blocks for the Description of Sediments.** M. I. GOLDMAN. **Treatise on Sedimentation.** W. H. TWENHOFEL. **Discussions at the Meeting of the Committee Held in Ann Arbor, Mich., December 27, 1923. Abstract of Sven Oden's Work on the Determination of the Effective Radius of Particles by Their Rate of Fall through a Fluid.** THOMAS WAYLAND VAUGHAN. **Flocculation of Colloids.** R. C. WELLS. **The Stratified Subsidence of Fine Particles.** C. E. MENDENHALL AND MAX MASON. **Notes and Comments Relating to Sediments and Sedimentation,** W. H. TWENHOFEL. **Discussion.** A. C. TROWBRIDGE. **Discussion.** MAX LITTLEFIELD. **Seasonal Deposition in Marine Waters.** R. W. SAYLES. **Discussion.** C. E. VAN ORSTRAND. **Remarks on the Study of Sedimentation by Artificial Precipitation.** HENRY S. WASHINGTON. A further abstract seems impractical. The abstractor believes however, that the article on Sven Oden's work on the determination of the effective radius, etc., by T. W. Vaughan and the article on "Flocculation of colloids" by R. C. Wells will be of special interest to water works people. The rest of the report is of more interest to geologists and geographists.—*A. M. Buswell.*

Surface Tension and Surface Energy and Their Influence on Chemical Phenomena. R. S. WILLOWS AND E. HATSCHEK. Third edition, pp. 136. London, J. and A. Churchill, 1923. Price 6s. 6d. Chem. & Ind., 42: 19, 477, 11 May, 1923. This edition prepared by Dr. Willows, is nearly twice the size of the first edition which appeared in 1915, and has been brought carefully up to date. The chief enlargements comprise an account of the important recent work of such investigators as Langmuir and Hardy on the properties of thin films, polarised molecules and lubrication. A clear and reasoned account is given of the main aspects of the subject, and its brief treatment is quite comprehensive. The book can be heartily recommended to those who wish to become acquainted with the essentials in this rapidly widening field, which interests biologists, physicists and chemists alike. (*J. W. McBain.*)—*A. M. Buswell.*

The Corrosion of Metals and Its Prevention. NATHAN VAN PATTEN. Annotated and carefully indexed bibliography, containing over two thousand references to literature of corrosion. Covers to January, 1923. Scope includes theory, for both ferrous and non-ferrous metals; electrolysis; and methods of combating. Invaluable aid to corrosion research. Typography, paper, and

binding leave nothing to be desired. Author was formerly Assistant Librarian Massachusetts Institute of Technology; is now Librarian of Queen's University, Kingston, Ontario, Canada. Limited edition. 180 pp.; cloth; $5.00. Apply to author. (Chance of unusual kind; merits close consideration of those concerned. ABSTR.)—*Frank Hannan.*

Bergey's Manual of Determinative Bacteriology. A Key for the Identification of Organisms of the Class Schizomycetes. By the Committee on Determinative Bacteriology, of the Society of American Bacteriologists, under the Chairmanship of David H. Bergey, Laboratory of Hygiene, University of Pennslyvania. Baltimore, Williams and Wilkins Company, 1923, pp. 442. Price $5.50. Much confusion has existed in the classification of the bacteria and perhaps no other group of living things have received worse treatment with respect to proper nomenclature. Early works on the classification of bacteria sought to distinguish them entirely on the basis of morphology. Later work however has shown this to be hardly possible. Wide differences have been shown in the physiological activity of morphologically similar organisms. It has, therefore, been necessary to recognize species by their physiological characteristics. This lead to several new attempts at systematic classifications. Much of this work was shown to be faulty by Buchanan who proposed a classification which conforms strictly to the Botanical Code of nomenclature. Bergey's Manual has encorporated much of Buchanan's classification of genera and has added descriptions of species with useful keys to aid in the identification of organisms. The Committee has brought together in this book information which heretofore it has been necessary to seek in a large number of original sources. It is the only work of this kind since the publication of the "Determinative Bacteriology," by Chester. The latter book is now far out of date.

In the new work the Genus Bacterium has been omitted entirely and in its place a number of other genera have been substituted. The colon group is included in the Genus Escherichia. What was formerly known as Bacterium coli now becomes Escherichia coli. Bacterium aerogenes is now Aerobacter aerogenes. The Genus Bacillus has been reserved for spore-bearing aerobes. New genera have been created for the non-spore-bearing organisms which were formerly included in this genus. For example, the etiological agent in typhoid fever is now designated as Eberthella typhi. It will be some time before the majority of bacteriological workers become familiar with the new nomenclature, but Bergey's Manual will doubtless be a great aid in bringing this about.—*R. C. Salter.*

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SELECTION OF AUXILIARIES FOR STEAM-OPERATED PUMPING STATIONS[1]

BY F. G. CUNNINGHAM[2]

Nowadays the logical selection of condenser and boiler-room auxiliaries in steam-operated pumping stations requires consideration of quite a number of alternate types of apparatus, whereas formerly nearly everything was driven by reciprocating steam-engines. All of the older types are still available in improved forms. In addition there are steam-jet ejectors and hydraulic air-pumps for producing vacuum, centrifugal pumps for an increasing variety of applications, and water-turbines, steam-turbines and electric motors for driving centrifugal pumps, stokers and fans. The tendency is toward the use of simple and reliable auxiliaries that require little attendance. More attention is paid to securing an economical heat-balance in the station and to keeping oil out of the condensate. The thermal economy in using steam extracted from the main units for feed-water or other heating is recognized. The increasing use of steam at high pressures and temperatures has militated to some extent

[1] This paper has been prepared under the direction of the Council to furnish useful imformation and to call forth discussion on pumping station betterments. Personnel of Committee No. 7, Pumping Station Betterments: Leonard A. Day, Chairman, St. Louis, Mo.; J. N. Chester, Pittsburgh, Pa.; F. G. Cunningham, Memphis, Tenn.; L. R. Howson, Chicago, Ill.; L. A. Quayle, Cleveland, Ohio.

[2] With Fuller and McClintock, New York, N. Y.

against the use of auxiliary steam-turbines and steam-engines, which ordinarily are less adapted than the main units to these steam conditions.

Water-turbines, operated by water taken from the pressure mains and returned to the suction system, in many cases are proving advantageous for driving auxiliaries. They may be used economically for driving even secondary pumps of large capacity and low head, where such pumps are located near large high-head pumps. In an application of this sort at Memphis, it was found that the steam indirectly used by water-driven secondary pumps, each of some 50 brake horsepower, would be less than half the requirement of the most efficient alternate driving device.

In stations where the make-up water has corrosive or scale-forming tendencies it may be advisable to pass it through a distilling plant. Where such a plant is provided, its design and the selection of other station auxiliaries must be considered together if a suitable heat balance is to be obtained. In fact, all of the equipment in any station should be considered collectively as well as individually, in order to secure the best over-all economy and a consistent and sufficient degree of reliability throughout.

What is desired of the station equipment, taken as a whole, is the highest general average when rated upon the following qualities:

Reliability	Ease of maintenance
Economy	Sustained efficiency
Simplicity	Adaptability to varying conditions
Accessibility	Durability

METHODS OF DRIVING AUXILIARIES

Depending upon their application, auxiliaries may be driven by one or more of the following methods: steam engines, steam turbines, steam ejectors, water turbines, electric motors and by direct attachment to another unit. The first three of these might be called direct methods, since their reliability depends upon no external factor except the maintenance of steam pressure. The last three methods are indirect, in that they require both the maintenance of steam pressure and the continued functioning of some other pieces of apparatus.

In general steam-driven auxiliaries have no superior in reliability. A station fully equipped with them has always within itself the means for resuming operations after a shut-down, provided only that steam pressure be maintained. Auxiliaries driven by indirect

methods should be used only where the reliability of their sources of energy is safeguarded sufficiently for the purpose. This point is occasionally overlooked, as in one case where two uniflow-engine-generators were equipped with electrically driven circulating pumps, making it quite difficult to start the generators after accidents had necessitated cutting off power from the main switchboard.

Besides being reliable, steam-engines and steam-turbines have the advantages of being capable of wide variations in speed and susceptible to automatic means of speed regulation. Their disadvantages are in the matters of maintenance, repair, lubrication and attendance in which the engines are inferior to the turbines and in which both are inferior to electric motors and water-turbines. A further objection to engines is that they introduce cylinder oil into the condensate, when their exhaust steam is used for feed water heating. Since auxiliaries are usually somewhat neglected, the steam consumption of small engines or turbines is apt to become excessive after a few years use and may become double the original rate.

Next to steam, water under pressure is usually the most reliable source of energy in the station and may be appropriately used for driving many auxiliaries, particularly those for condensers. Due to the fact that the main pumps usually operate at high efficiencies, water-driven auxiliaries frequently are far more economical in power than those of any other type. They are also simple, easy to maintain and are more apt to sustain their efficiences than small engines or turbines. They are capable of speed variation to a moderate extent. Where their use is contemplated, investigation should be made to see that the head and speed conditions are suitable.

The suitability of electrically-driven auxiliaries in a given case depends upon the reliability and economy with which power is generated. Usually it is necessary to have two or more generators in a station to provide reliable plant lighting. If these are of an economical type the power may be used to drive some of the auxiliaries. No matter what precautions are taken to secure reliability there is always the possibility of interruptions in electrical power circuits due to fuses blowing out and similar causes. Electrically-driven apparatus, therefore, should not be used where absolute continuity of service is required, as for condenser auxiliaries of high service pumps delivering water directly into the mains. Where interruptions of five or ten minutes duration can be tolerated they may be made sufficiently reliable.

While station generators usually are essential, they often must operate with an extremely poor load factor, the load varying from a few lights to a combination of motors for the shop, crane and conveying equipment. In such cases the addition to the load of a few small motor-driven auxiliaries operating almost continuously may greatly improve the load factor and not materially increase the steam consumption of the generator. For driving small station generators having poor load factors nothing is as economical as uniflow-engines, which may be designed to have an almost flat water-rate curve from one-third load to full load.

Auxiliaries driven by attachments to the main units are seldom used except as condenser auxiliaries. In such service their reliability is equal to that of the main unit served and is sufficient. One disadvantage of attached condenser auxiliaries which may be more or less important is that the vacum cannot be established before the unit is in operation.

RELIABILITY

The reliability of a water supply system should be such that no single failure in any part could impair its ability to maintain full domestic and fire service. If the system includes storage reservoirs or basins, the need for continuous operation of the station is lessened to some extent, at least as regards that part of the equipment devoted to filling the reservoirs. Usually there is considerable storage provided between low-lift and high-lift stages of pumping, as in filter plant installations, and no storage is provided beyond the high service pumps. In such cases, types of auxiliaries might be used appropriately in the low-service pumping that would be unsuitable for the high-service work. The presence or absence of reservoirs, therefore, have a direct effect upon the selection and arrangement of auxiliaries in the station.

In planning to make all parts of the station equipment sufficiently reliable it is difficult to keep out inconsistencies, but the more serious ones at least can be avoided. For example, if there is only one reserve main pumping unit in a station beyond the number necessary to maintain maximum service, it should be made impossible for any single breakdown of a valve, run of pipe or piece of equipment to result in two or more main pumps being shut down. Water pressure (unless from gravity storage) and electric current should not be depended upon to such an extent that the station could not be

brought into operation without them. One good test for reliability is to assume the station to be entirely shut down and no pressure in the mains and then consider what steps would be necessary to bring it into operation again. While this is a rather severe criterion, it usually will be found that the deficiencies discovered in this way may be remedied by providing a few simple emergency devices or connections.

COMPARING POWER REQUIREMENTS OF AUXILIARIES

In considering various types of auxiliaries their power requirement cannot be compared directly upon a proportional basis, because the sources of steam used in feed water or other heating must be taken into account. The first step is to determine the average value of a pound of steam, which will be the sum of the fixed charges and operating costs of the steam-generating plant divided by the average station evaporation. In the next step two general cases must be considered, namely:

Case 1. Stations in which it is not practicable to extract steam from the principal condensing units at pressures slightly above atmospheric and to use such steam for feed water or other heating. In such stations the steam consumption of steam-driven, non-condensing, auxiliaries is of little consequence as long as all of the exhaust steam may be utilized for heating. All excess exhaust steam and all steam used directly or indirectly by condensing auxiliaries, auxiliaries driven by water bled from the mains, and auxiliaries attached to the main units, should be charged with the full value of the steam used.

Case 2. Stations in which extraction of steam from the principal condensing units is practicable. All extracted steam used for heating should be charged only as the amount of steam that must be added at the throttles of the extraction units to replace the amount extracted. This may be anywhere from 20 to 70 per cent of the amount extracted. All steam required by steam-driven non-condensing auxiliaries and utilized for heating may be regarded as diminishing in the same amount the quantity of steam that may be extracted from the main units, and should be charged with the value of the work that this amount of steam could have done had it been passed through the main units and extracted. The amount thus charged may be anywhere from 30 to 80 per cent of that actually used. Excess exhaust steam and steam used by all auxiliaries except steam-driven non-condensing auxiliaries should be charged at full value.

In both the above cases, when auxiliaries are driven by water-power or electricity or when they are attached to the main units, they should bear their proportionate share of the fixed charges on the engine room equipment serving them, in addition to the charges described above.

HEAT BALANCE

When the exhaust steam from all of the non-condensing auxiliaries, the steam bled from main units, the drips from jackets and steam pipes, and other steam or hot water from similar sources are collected and used for feed water and other essential heating, and when the total heat from such sources is just sufficient for the purpose, a heat balance is secured. In the absence of an economizer and distilling apparatus the desirable feed temperature is of course about 210 degrees.

While success in securing a heat balance is essential, it does not necessarily follow that the greatest practicable thermal economy has been obtained. The only ultimate criterion for this is to minimize the total station evaporation, which will vary with different methods of securing a balance. In the first place, the initial temperature of the condensate should be kept as high as the vacuum temperature will permit, either by suitable condenser design or by the use of vacuum exhaust heaters.

Where steam extraction is impracticable steam-driven non-condensing auxiliaries will give the highest thermal economy, as long as there is no waste or excess of exhaust steam. In such cases it is better to have too little than too much exhaust steam, on account of the tendency for such auxiliaries to deteriorate in efficiency. The deficiency can be supplied with live steam.

Where steam extraction is practicable, the steam extracted and the steam required directly or indirectly to drive auxiliaries should be rated arbitrarily after the method described in the preceding section. The heat balance which will then give the greatest thermal economy will be the one in which the total of the rated values of steam extracted and steam used by auxiliaries is least.

To illustrate the ecomony of steam extraction, let us assume that in a given station fifteen per cent of the total station evaporation is needed for feed water and other heating and that just this amount is supplied by the exhaust from non-condensing auxiliaries. Now suppose that, by substituting other types of auxiliaries, their steam con-

sumption could be reduced to four per cent of the station evaporation. Then most of the steam used in feed water heating could be bled from the main units, and the gain would be roughly the amount of work in the main units done by the extracted steam in expanding from throttle pressure to the bleeder pressure. In the above case the gain would be four per cent or more of the station evaporation.

The extraction of steam from the main units, while usually economical, sometimes raises complex questions and when it is contemplated the matter should be taken up with the manufacturers. One of the difficulties with turbines is in finding points for extraction where the pressure will be low and still under all load conditions will be above atmospheric pressure. It is only practicable, of course, in multi-stage turbines or multi-expansion engines.

In computing steam-rates for heat balance it should be noted that some of the auxiliaries may require nearly maximum power at all times, either through inability or through failure of the operators to adjust them to changes in conditions.

CONDENSER EQUIPMENT

In waterworks practice, condensers and auxiliaries are usually bought with the main unit which they serve. The determination of their size and type is frequently left to the manufacturer of the main unit, especially when he guarantees the overall economy of the outfit. The manufacturer, however, is not usually informed upon all the details of station economies, such as its heat balance, cost of steam, etc. It is better for the purchaser to gather all the necessary data, to analyze the situation in advance, and then to specify definitely what he wants.

CONDENSERS

Condensers of the surface type are ordinarily the only ones well adapted to waterworks service. Those of other types need no discussion here. Condensers for pumping engines or steam-turbine pumping units may be either of the waterworks type (in which all of the water pumped by the unit passes through the condenser and outside of the tubes) or of the standard type. Surface condensers for other service are practically always of the standard type.

In selecting a condenser for a pumping unit the choice between the waterworks and the standard type is first to be settled. The only

advantages of the waterworks type are that it dispenses with a circulating pump and the large volume of cooling water results in a greater mean difference between cooling water and exhaust steam temperatures. Its disadvantages are as follows:

1. It causes a loss of head in all of the water passing through the main pump. This loss of energy may be greater than the power required to drive the circulating pump for the standard type, particularly when the total pumping head of the main unit is low or the capacity large.

2. Due to the low velocity and uneven distribution of cooling water, the heat transfer constant is much less than in the standard type. This fact may offset the advantage of large temperature difference.

3. It is difficult to clean where the tubes are fouled by the water.

4. It is heavier and more expensive than the other type, even when the surface is the same.

5. It chills all of the condensate down practically to the water temperature, thus wasting heat.

6. Usually located in the suction pipe, there is not much chance for choice as to its position and frequently it must be placed in dark, hot or inaccessible places, also necessitating locating the auxiliary pumps in similar places near-by.

The waterworks type of condenser has been generally used, particularly in connection with pumping engines. Its choice is frequently justified, but custom seems to have led to its use in some cases when the standard condenser might have been better.

When a condenser of the waterworks type is to be bought, the purchaser should specify in addition to mechanical details the vacuum at given loads, the maximum heat-transfer coefficient and the maximum loss of head in the condenser. The loss of head should not be more than two feet and preferably should be less than one. It can be kept small by providing liberal space between the outermost tubes and the shell.

When a condenser of the standard type is to be bought, the purchaser should specify, in addition to the above, the maximum rise in cooling water temperature. The assigning of logical values for these quantities requires consideration, among other things, of the power required to drive the circulating pump and the cost of furnishing that power. The required cooling surface, and therefore the first cost of the condenser, will be decreased by increasing the water

velocity through the tubes or by increasing the quantity of cooling water, or by both, but the cost of driving the circulating pump will also be increased as a result.

By suitable design, standard condensers may be made to keep the temperature of the condensate within 3 to 5 degrees of the exhaust temperature and it is well to specify that this be done.

CONDENSER AUXILIARIES FOR STEAM-TURBINE UNITS

Circulating Pumps. Circulating pumps are nearly always of the centrifugal type and may be driven by electric motors, steam or water turbines or may be direct-connected to the centrifugal pump shaft of the main unit.

The direct-connected circulating pumps usually are the most economical of power. Their disadvantage is that a vacuum cannot be established before the main unit is in operation.

The circulating water is usually taken from the suction piping supplying the main unit and, after passing through the condenser, is returned to the same piping. If the piping in the cooling water circuit be tight, and the highest point be no more than 30 feet above the supply level, the total head under which the circulating pump must operate will be limited to the friction losses in the piping and in the condenser, since the water will pass over the high pionts in the circuit by syphonic action.

Water turbines, direct-connected to the circulating pumps, often make a very satisfactory driving motor. The driving water is taken from the discharge piping of the main pump and returned to the main suction piping. If the economy of the main pumps be reasonably good, this method usually will require less boiler steam than any type of steam-driven or electrically-driven circulating pump.

Occasionally electrically-driven circulating pumps may be the logical choice, as in stations where electric power is produced reliably and economically within the station. Where continuous operation is important, they are inferior to pumps driven by the other means, on account of the danger of interruptions in electrical circuits.

Circulating pumps driven by steam turbines, connected thereto either directly or through reduction gears, are generally applicable only to large installations where the main unit develops one thousand horse-power or more. In a smaller installation the power requirement of the circulating pump is so small that the steam consumption of the driving turbine is excessive in proportion.

In the sizes and for the heads ordinarily required the efficiency of centrifugal circulating pumps will be quite good, ranging from 60 to 80 per cent. Since the total head upon them is usually low the suction lift should be small, and preferably less than 10 feet, to secure good efficiency. The efficiency of a water-turbine driving a circulating pump is usually considerably higher than that of the pump. The water rate of non-condensing auxiliary steam turbines suitable for driving circulating pumps will range from 130 pounds per B. H. P. for turbines of 4 brake-horse-power, to 50 pounds for the largest size required in waterworks service.

Vacuum and Condensate Pumps. Wet vacuum pumps, or those removing both air and condensate from the condenser, when used with surface condensers, are practically always driven by steam engines, and may be either of the piston or the rotary, positive displacement type. They are used most widely where vacua of less than 28 inches are required, but some makes are suitable for high vacuum service. They cannot elevate the condensate more than a few feet above their own level, but when high lifts are required those of the rotary type are sometimes provided with an auxiliary rotary condensate pump mounted upon an extension of the shaft. Of the two types, the piston pumps usually will be the lower in first cost and maintenance cost and will require more steam for operation.

Dry vacuum pumps are used most commonly for high vacuum service, but considerations of simplicity and the cost of furnishing driving power may make some types of them appropriate for low vacuum work. Where used as auxiliaries for steam-turbine units with surface condensers they may be of the steam-driven, piston, the steam-driven, rotary, the steam-jet ejector or the hydraulic type. The displacement capacity and driving power required in dry vacuum pumps will vary about in inverse proportion to the absolute pressure in the condenser. The sizes usually needed in waterworks pumping stations are small and the power requirement, measured in brake-horse-power, is also small, although their low efficiency makes their steam consumption important.

Steam-driven, dry-vacuum pumps are best suited for use in connection with large units. A pumping unit using 8000 pounds of steam per hour, operating with 28.5 inches of vacuum and fitted with a steam-driven air pump, will require an air pump power of only 2 horse-power, but the steam consumption of the air pump will be over 100 pounds per horse-power-hour. As the size of the steam-driven

air pumps is increased their steam rate becomes better until a rate of 40 pounds per horse-power-hour may be had with pumps of 15 horse-power or more.

Hydraulic air pumps and steam-jet ejectors may be secured in sizes consistent with main units of about 300 horse-power or larger. With other conditions equal, their power requirement will vary about in direct proportion to the size of the unit served, differing from that of steam-engine-driven pumps in this respect, so that their most favorable comparison with the engine-driven pumps in the matter of power will occur in the smaller sizes.

Hydraulic air pumps, for general service, are equipped with a pumping element to supply the hurling water and, depending upon the manufacture, this element may be in the same casing as the air-displacement element or in a separate casing. For water-works service, hydraulic air-pumps having an independent air-displacement element, as in those of the Worthington type, are usually preferable. No pumping element is usually needed because the hurling water may be taken from the mains more economically than from a hurling-water pump. If the head in the mains is as much as several hundred feet, however, it may be more economical to use a water-turbine-driven hurling-water pump. When the hurling water is taken from the mains it is returned to the system at some convenient point on the suction side of the main pumps. In such cases the air pump must be set above the highest static water level in the main suction system. When the hurling water is supplied by the auxiliary pumping element, the water is circulated through a tank on a closed circuit and the entire apparatus may be placed at any convenient elevation. Worthington hydraulic air pumps require hurling water under a head of not less than 80 feet. When the pressure head in the mains is considerably more than 80 feet the hurling water is sometimes passed through a water-turbine driving the condensate pump, thus utilizing all or part of the excess head. When hydraulic air pumps can be supplied with water from the main pumps they are apt to be more economical of power than either the steam-driven pumps or the steam-jet ejectors, just reversing the usually-accepted relationship.

Steam-jet ejectors usually must be of the two-stage type to produce satisfactory vacua. Those having surface inter-condensers, or inter-coolers, between the stages are generally preferable. For similar conditions the steam consumption of the two-stage ejectors without inter-coolers is about double that of ejectors with inter-

coolers. When the steam from the steam-jet ejectors is utilized in feed-water heating or other heating it is often led to an open heater where the entrained air may be liberated. Sometimes there is provided an after cooler in which the effluent steam is condensed as in a closed heater. Unless the cooling water used in ejectors be feed-water, the heat abstracted obviously will be wasted. When the main units are of 600 horse-power or less capacity, the two-stage steam-jet ejector with inter-coolers will require no more steam than a steam-driven, piston-type pump. With larger units the comparison will favor the latter type of air pump. One of the objections to both steam-jet ejectors and hydraulic vacuum pumps is the lack of opportunity for capacity variations. In large installations this difficulty is sometimes partially met by providing two air pumps, one of which may be shut down in seasons when the vacuum is low.

Condensate pumps elevating the condensate to the heater may be of the centrifugal type and usually driven by water-turbines or electric motors, or they may be direct-acting, steam pumps. In some cases centrifugal condensate pumps may be driven from the shaft of an adjoining auxiliary serving the same main unit. The net work done in most cases is very small and the efficiency of either type is low. When the water heads are suitable and the main pumping units fairly economical the water-turbine-driven centrifugal pumps will require only one-half to one-quarter as much power as the steam pumps. Electrically-driven, centrifugal condensate pumps may be advantageous when current is produced cheaply within the station and where occasional interruptions in service would not be especially serious.

CONDENSER AUXILIARIES FOR PUMPING ENGINES

Pumping engines are well adapted to driving attached, reciprocating air-pumps and condensate-pumps but cannot be fitted economically with attached circulating pumps. Turbo-centrifugal pumping units may be directly connected to their circulating pumps but not to their air and condensate pumps. The most economical vacuum is of course somewhat lower with pumping engines than with turbines. Except as it may be influenced by these facts, the problem of choosing condensing equipment for the two classes of units is generally the same. Auxiliaries of any of the types discussed in the preceding paragraphs may be used more or less fitly, in connection with pumping engines. Attached air pumps and condensate pumps are reliable, easy to

maintain and highly economical of power, but under equal conditions they are higher in first cost than any other type of separatively-driven pumps. The attached air pump must have relatively a large displacement capacity to give satisfactory service in starting and at low speeds.

COMPARATIVE POWER REQUIREMENTS OF CONDENSER AUXILIARIES

In order to show approximately the comparative power requirements of various types of condenser auxiliaries, the tabulation below was compiled mostly from data offered by bidders at Memphis, Tenn., in connection with a 650 brake-horse-power, 15 million gallon, steam-turbine-centrifugal pumping unit, operating under 200 feet total head. The main unit requires about 15 pounds of steam per water-horse-power-hour and operates at 28.5 inches of vacuum. The power requirements are expressed in pounds of live steam chargeable directly or indirectly to the auxiliaries. The condensate is lifted through a total head of 80 feet, including suction.

	BRAKE HORSE POWER	POUNDS OF STEAM PER HOUR
Circulating pump:		
Driven by main pump shaft	7.0	84
Driven by non-condensing steam turbine	7.0	550
Driven by water-turbine	7.0	120
Driven by electric motor, using current from house generator (generated at 24 pounds per KWH.)	7.0	175
Dry air pump:		
Steam-driven, flywheel, piston pump, non-condensing	2.0	220
Hydraulic, using water from mains	5.0	75
Same with separate hurling-water pump, driven by non-condensing steam turbine	7.5	600
Steam-jet ejector, 2-stage with inter-condensers		200
Condensate pump:		
Direct-acting steam pump	0.6	150
Electrically-driven centrifugal, using current from house generator	2.0	60
Water-turbine-driven centrifugal, using water from mains	4.0	60

The figures on water-driven condensate pumps and air pumps are based upon the driving water being passed through these auxiliaries in series. The data in the tabulation are directly applicable only to this particular installation.

A cross-compound pumping engine designed for the same head and capacity as the above unit, operating with 28 inches of vacuum, would require about 60 pounds of steam per hour to drive attached air pump and condensate pump.

BOILER FEED PUMPS

Except in the largest pumping stations there is not much opportunity for choice of type of boiler feed pumps. Unless the average station evaporation is more than 1000 pounds per minute it is doubtful whether centrifugal feed pumps will be found advisable. The objectionable features in centrifugal feed pumps of small capacity are their low efficiency and narrowness of water passages. A combination of high head and small capacity results in narrow impellers and poor efficiency. A pump with a capacity of less than 100 gallons per minute would have an opening at the tips of the impellers not much wider than a crack. With impellers of this shape any tendency of the water to erode the impellers or deposit scale upon them and any undue wear of the rings have a serious effect upon the performance of the pump. In capacities of 150 gallons per minute the efficiency and operating capacities of centrifugal pumps are reasonably satisfactory and both improve with further increase in capacity. As compared with direct-acting pumps their advantages in the way of simplicity, ease of maintenance and producing a steady water-flow are manifest.

The choice of driving mechanism for centrifugal feed pumps seems to be limited to steam turbines and electric motors. Investigations for the new Kansas City pumping station indicated that water turbines would be unsatisfactory, as the combination of considerable power requirement and low pump efficiency resulted in too large a driving-water demand. In this case it is planned to use electrically-driven centrifugal feed pumps ordinarily and to aid reliability by providing a reserve steam pump.

For stations of small or medium capacity nothing appears to be better than direct-acting steam pumps of the plunger type.

STOKER DRIVES

Vertical, high-speed, steam engines are probably the most common type of stoker-driving mechanism for pumping stations, except for stokers of the steam ram type. Steam engines are unequaled in adaptability to graduated, wide range, automatic, speed regulation, which is a highly desirable quality in stoker mechanism.

Electric motors are used considerably. They possess the advantage of simplicity. If their current supply is generated economically they may be more economical of power than steam stoker engines. They are poorly adapted to automatic speed regulation. They are somewhat deficient in reliability, due to the possibility of trouble in the electrical circuits, but where underfeed stokers are used the amount of fuel on the grates will keep up steam pressure long enough to remedy minor troubles of such nature.

Water turbines have been little used for driving stokers but seem to offer fair possibilities in some cases. They equal electric motors in simplicity and considering the source of power supply would usually excel them in power economy and reliability. They are easily adapted to automatic speed control through a throttling valve, but cannot operate through as wide a speed-range as either steam engines or electric motors.

Steam turbines do not seem well adapted for stoker drives in waterworks stations, although used considerably in large power plants. In the smaller sizes it is doubtful if their upkeep cost is less than that of an engine, and their power economy is very poor. Where the boiler units are larger than 250 horse-power, individual driving mechanisms for each stoker are desirable, as they permit independent speed adjustment and increase the reliability of the station. Frequently a common-line-shaft for the entire boiler room is used and driven by one engine or motor with a duplicate engine or motor in reserve. This arrangement is simple but has not much else to recommend it.

Individual steam-driven stoker engines are being used in the new Memphis pumping station where the boiler units are of 350 horse-power nominal capacity. Ordinarily each engine will drive its stoker by direct connection to the speed shaft. Short jack-shafts connecting the stokers in pairs are provided in such manner that if desired one stoker engine may be used to drive its own stoker directly and also drive the neighboring stoker through the jack-shaft, in which case the neighboring engine will be disconnected from the stoker and jack-shaft. This arrangement is for emergency use and ordinarily the jack-shaft will be idle.

When stokers are driven in groups, a variable speed transmission device such as the Reeves is sometimes inserted between the line shaft and each stoker. This arrangement is preferable to a common-drive system, but is not readily adaptable to automatic control.

MECHANICAL DRAFT DRIVING MECHANISM

Modern mechanical draft fans are usually of the high-speed multi-vane type and must be driven by steam turbines or electric motors. If driven by vertical engines the maximum rotative speeds of fans are usually about 400 R.P.M. and they must be of the steel plate type. Steel plate fans require considerable space and their characteristics are usually less satisfactory than those of multi-vane fans. Their principal advantage lies in their adaptability to steam engine speeds.

For driving high speed fans the choice between steam turbines and motors depends upon the individual station conditions. Motors are desirable on account of their simplicity and in some cases on account of economy, but are not so well adapted as turbines to automatic speed regulation and are slightly deficient in reliability. With underfeed stokers continuous operations of the fans is essential; with chain grate stokers the fans may be essential only for high ratings.

Fans should have driving mechanisms entirely independent of those for the stokers. The air supply to each boiler should be controlled individually and preferably by automatic means, either by varying the speed of individual fans, by varying the positions of individual dampers in the air supply ducts or by both methods. The use of dampers to control air supply results in waste of fan-drive power and this is about the only objection to such use of them. Where electric power is produced reliably and economically within the station, electrically-driven fans with dampers for air control may be preferable to either turbine-driven or electrically-driven fans with automatic speed regulation. Automatic speed controllers for electric motors are expensive and complex. Manual speed controllers are simple and inexpensive and often may be used to advantage where motors are used to drive the fans. The shaft power required by fans varies about as the cube of the speed; hence reducing the speed will substantially reduce the electrical input, no matter whether the motors be of the alternating or the direct current type. By using the manual speed controllers the fans speed may be approximately adapted to the boiler load and an automatically operated damper in the air duct may be used for closer regulation of the air supply.

When fans are driven by steam turbines, they may be connected directly or through reduction gears. The reduction gear units are

more economical of steam and decision as to whether they should be used depends upon their size and cost and upon the value of the steam saved.

Frequently several boilers are served by a common main air duct and supplied by a single large fan, with a duplicate fan in reserve. Choice between this arrangement and one individual fan depends upon the number and size of boilers, load variations and other conditions in the station. Individual fans permit of short and direct air ducts and of regulating the fan speeds independently to suit the requirements of each boiler. They also permit of the fans being designed for a reasonably narrow capacity range, since the range corresponds to the load variations of only one boiler.

A common fan system has the advantage of simplicity but requires control of the air supply at the individual air duct damper and requires the fans to be operated through a wide capacity range, corresponding to the range from minimum to maximum boiler room load. Extreme load variations in the ratio of four to one are not uncommon in pumping station boiler rooms and the corresponding ratio of fan power requirement might be as high as 15 to 1. Under these circumstances a common fan system would be wasteful of power, since a fan cannot be designed for economical operation through such a wide range of conditions.

WATER WORKS PUMPING STATIONS[1]

By Charles B. Burdick[2]

It is the purpose of this paper to outline the general principles of pumping station design and to cite a few examples of recent construction, referring more particularly to the buildings for housing water works equipment.

The average water works involves an investment of not less than $35.00 per capita or $3,500,000 in a city of 100,000 people. Of this large investment often not more than ten per cent represents structures visible to the eye of the ordinary citizen. To the casual observer water works buildings present the only evidence of the excellence of the plant, except the water delivered, and his impression as to the property is likely to be based upon what he can see.

Fundamentally there is no reason why the water works station should not present the same attractive appearance as the city hall or any other municipal building. It should be permanent, clean, and as easily kept clean as a modern hospital, for it handles a commodity used in every home. An ornate design justified in a city hall or a courthouse would be out of place in a pumping station. Rather it should represent the masculine in architecture without undue pretension, strong and permanent in its lines and materials, frankly adapted to its purpose, and presenting an appearance agreeable to the eye. This will require compliance with laws of good architecture, which have been thus concisely expressed by Horatio Greenough:

> A scientific arrangement of spaces and forms to functions and site; an emphasis of features proportioned to their gradated importance in function; color and ornament to be decided and arranged and varied by strictly organic laws having a distinct reason for each decision; the entire and immediate banishment of all make-shift and make-believe.

PERMANENCE

Water works construction is now sufficiently standardized so that it is possible to lay out pumping plants subject to enlargement in

[1] Presented before the Detroit Convention, May 22, 1923.

[2] Alvord, Burdick and Howson, Engineers, Chicago.

such manner that the buildings may be useful indefinitely. The pumping and power equipment should be arranged with the idea of expansion. It is usually practicable to build only for a moderate time in the future, but it costs little to lay down the indefinite future additions on paper, and so to locate the building, and so to arrange the equipment that extensions may be made without destroying the usefullness of important parts of the plant. It is all too common to find layouts that have expanded piecemeal according to the path of least expense, which must be torn out and rebuilt, because further expansion is impracticable. We can see farther into the future today than was possible a generation ago. There may be radical improvements in water works equipment hereafter, but, if the general plan of expansion has sufficient elasticity, the probable future can be accommodated.

In the ordinary water works plant, steam operated, there is, first, the heart of the plant, so-to speak, consisting of the main entrance, offices, and possibly a laboratory which may be grouped, and will need little further expansion. The engine room and the boiler room, after providing for the present and the immediate future, may be expanded along parallel lines without necessarily spoiling the architectural symmetry. It is wise to be liberal in selecting dimensions. This tends toward permanency.

If the water is filtered, it is desirable in small pumping stations to centralize the "business end" of all the station operations on account of facility in supervision. This complicates the design, especially the provision for future expansion, and centralization is not always possible when filtration is added to an old water works. In the layout of a new plant, however, it is practicable so to coördinate the expansion of pump room, boiler room, filter plant, coagulation basin, and clear well, that each may be enlarged in an orderly manner with convenience of access between the operating parts and the administrative center of the group. Basins and reservoirs may expand, if necessary, forward from the building, utilizing a space covered over by lawn. Plants in cities up to 100,000 population, or somewhat more, may thus be designed without the necessity for separating the pumping and filtration plants. A compact arrangement is quite necessary for economical operation in a small city where it may be desirable to operate filters without adding to the number of employees.

FIREPROOF CONSTRUCTION

The modern water works station is fireproof throughout for obvious reasons. Permanency requires it. It should be the last building to burn in any community. Many water works stations are practically fireproof except for the roof construction, windows, and the doors. It is practicable to build stations today without using a stick of wood, and at moderate costs as compared to wood. Mill-work has increased in price to such extent that there is little difference between wood and metal frames, and concrete and tile construction is generally used for roofs in the most modern stations.

BUILDING MATERIALS

For underground structures or for other structures, more or less concealed and protected from the weather, concrete gives excellent service. Where exposed to view or subjected to the action of the elements, it is not proving a satisfactory building material. Wherever possible it is wise to design reservoirs so that they may be filled over and sodded, thus protecting the concrete from the expansion and contraction of hot sun and winter cold, and incidentally better protecting the water from extremes of temperature

For superstructures, brick and stone are the most satisfactory materials for exteriors, terra cotta may be useful upon the interior or exterior. Upon the interior the surface should be clean and non-absorbent. Concrete floors are only satisfactory in the cheaper structures where it may be successfully used if covered with a heavy non-absorbent paint especially adapted to concrete. In the better stations terrazzo or tile is justified.

Walls, particularly where damp, as in the pumping pits, should be faced with a non-absorbent substance such as enamel brick built at least head high. Above this plane pressed brick is satisfactory. At present a rock plaster is available almost as hard as stone which can be worked into very attractive panel designs at moderate cost.

For the roof, exposed steel trusses are generally used with steel purlines and a roof covering of reinforced concrete or tile. In order to prevent sweating in cold weather a double ceiling is desirable. This may be accomplished by rock plaster on metal lath hung from the purlines. Thin concrete roofs usually become a nuisance at certain times from dripping. A single thickness of 5 inches is usually sufficient to prevent the serious collection of drops. A double ceiling

completely eliminates the trouble and costs comparatively little more. Skylights and ventilators must be guarded with gutters for satisfactory results.

It is proposed to cite a few examples of recent pumping station construction with illustrations and figures of cost. Practically all of this work has been done in co-operation with Mr. Victor A. Matteson, Architect, Chicago.

DES MOINES PUMPING STATION

The new 21st Street pumping station at Des Moines, Iowa is illustrated in figures 1 to 5. This is a steam station. It pumps the entire water supply of the city in one operation from the ground water collecting galleries into the pipe system against direct pressure. The rates of pumpage at the present time are as follows:

Minimum night rate, m.g.d.	6.5
Average day, m.g.d.	10.0
Momentary peak, m.g.d.	18.0
Maximum fire demand, m.g.d.	24.0

The pumping plant consists of three DeLaval turbo-centrifugal geared units, two of 15, and one 25 million gallons capacity. These pumps operate at a 269 feet total head with 200 pounds boiler pressure and 100° of superheat. The two smaller of these pumps developed duties on test ranging from 150 to 114 million foot pounds per thousand pounds of steam at full capacity and half capacity respectively. The larger pump is guaranteed to deliver 161 mil. duty at full, 164 at three-fourths and 144 at one-half capacity.

BOILER PLANT

The boiler plant consists of four 323 H.P. Springfield water tube boilers. One boiler is served by a LaClede-Christy natural draft chain grate stoker. Three boilers are equipped with Harrington chain grate stokers operating on natural draft up to 125 per cent rating, and forced draft up to 200 per cent rating. The plant burns a low grade of bituminous screenings (Poke County, Iowa), ranging from 8,000 to 10,000 B.T.U. The individual boilers and stokers in this plant developed on test from 72 to 74 per cent efficiency when operating on natural draft slightly above boiler rating, and 70 per cent on forced draft at slightly under 200 per cent rating.

FIG. 1. WATER WORKS PUMPING STATION, DES MOINES, IOWA
Note gantry crane for coal handling in rear of building

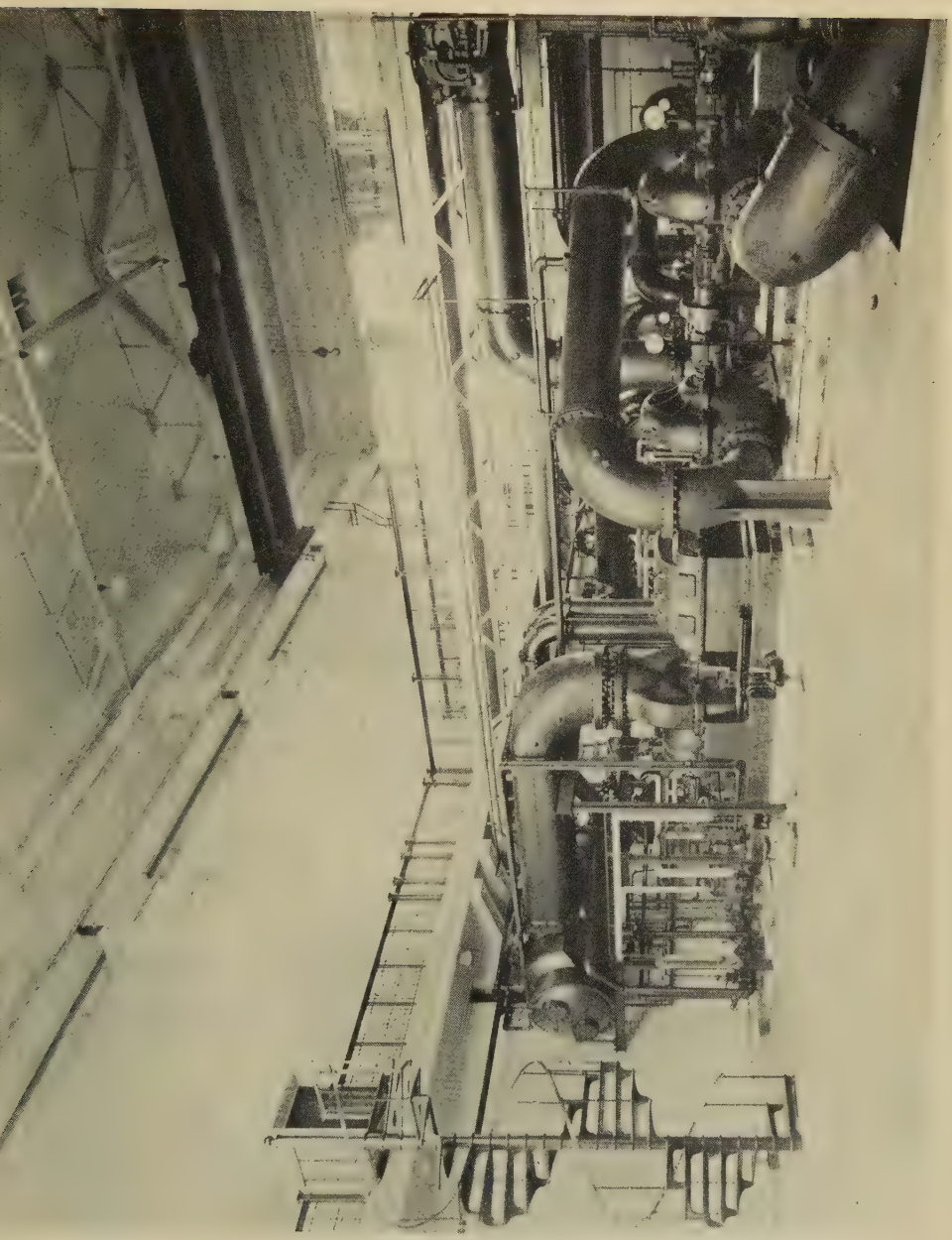


FIG. 2. PUMP ROOM, DES MOINES PUMPING STATION, HOUSING TURBO CENTRIFUGAL PUMPING EQUIPMENT

FIG. 3. IMPROVEMENT OF GROUNDS, DES MOINES PUMPING STATION

This boiler and pumping plant serves the city on about half the tonnage of fuel per unit of water pumped required by the old pumping station, served by hand-fired tubular boilers and compound crank and flywheel pumps. The greater part of the saving is secured by the improved boiler plant.

COAL HANDLING

The matter of handling coal is a difficult one in a water works boiler plant by reason of the magnitude of the peak load as compared to the comparatively small average load. Coal handling equipment of the type adapted to electric lighting practice often fails to show economy when applied to the small tonnage burned by water works, on account of fixed charges. The device adopted at Des Moines

FIG. 4. SHOPS AND GARAGE BUILDING, DES MOINES WATER WORKS

consists of a gantry crane feeding from cars or coal pocket to an overhead bin in the boiler room. It also picks up ashes, dumped to the ash pocket by hand, loading the same into cars or trucks. By the use of this crane one man unloads all cars not dumped, and handles all coal and all ashes for a 24 hour shift in three hours or less. The coal handling scheme at Des Moines at the present price of labor a little more than "breaks even" with hand coal handling, labor and fixed charges considered. Its installation was considered warranted in view of the probable future increased cost of labor.

BUILDING GROUP

The group of buildings comprising the new water works pumping station at Des Moines consists of the main pumping station and boiler room, a shop and garage building for the accommodation of all

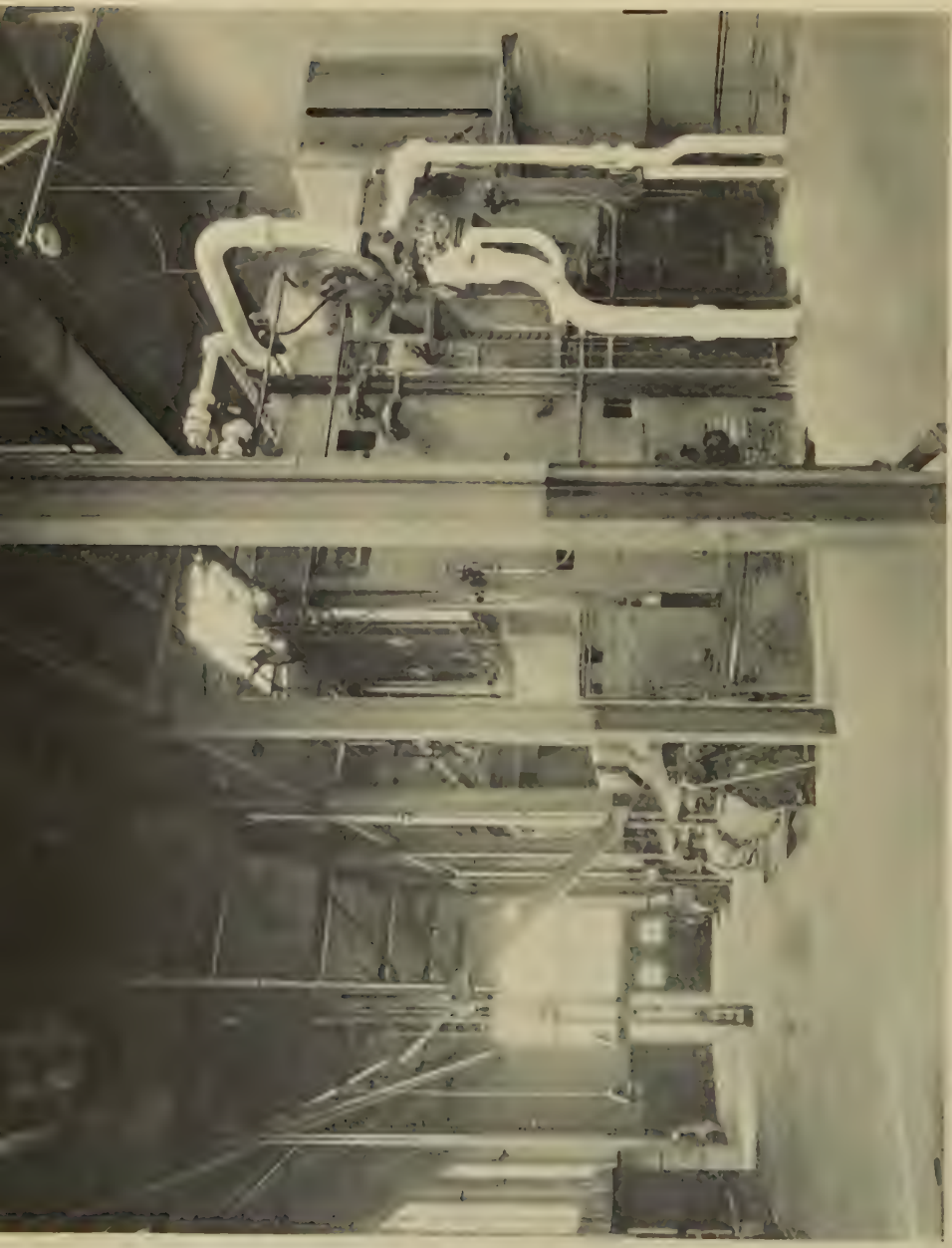


FIG. 5. BOILER ROOM, DES MOINES PUMPING STATION

automobiles and trucks used by the Water Department, a warehouse, with pipe yard adjoining, for storing pipe, fittings and miscellaneous supplies; also a group of cottages housing four families of water works employees.

The main pumping station consists of a pump room containing space for eighty million gallons in pumping capacity. Fifty-five million gallons capacity is at present installed. The boiler room contains 1300 H.P. in boilers and space is provided for enlargement that may be required after 1940.

Adjoining the main entrance to the pumping station are located an office for the chief engineer, a laboratory, and toilet accommodations for the public. Employees' toilet rooms are located between the pump and boiler rooms. Galleries are provided in the pump room for the accommodation of visitors, so that the pump room may be seen without interfering with the operation of machinery.

All foundations are constructed of heavy reinforced concrete. The pumps are set 13 feet below the high water line, thus necessitating a heavy pump pit floor and walls to resist upward and inward pressure. The pumps are located in this way in order to draw from the gallery system in extreme low water.

The pump room is finished with terrazzo floors and white enamel brick walls up to the top of the wainscot at grade line. Above this point the walls are paneled and coated with rock plaster. The roof is supported by steel trusses carrying Federal cement tile with a composition roof covering. Steel windows, doors and trim are used throughout.

The boiler room is finished with concrete floors, with walls of common brick painted. The entry way and halls are floored with terrazzo, and provided with terra cotta walls. The exterior of the building is of dark red tapestry brick with Bedford stone trim.

The shops and garage building exterior finish is similar to pump house. The interior is finished with concrete floors and common brick walls, and the whole is surmounted by a timber mill construction roof, slow burning type, and covered with composition roofing. Steel window sashes are used. The remaining millwork is of wood. This building provides all facilities for the maintenance of the water works motive power and contains a wood shop, machine shop, paint shop and in the rear a stable for the accommodation of one team.

The warehouse building resembles a small freight house in general plan with an office space in the front where all water works labor is

handled and assigned to its daily tasks. A siding runs parallel with the warehouse with platforms on both sides, so that freight unloaded may be wheeled through the storeroom and loaded on wagons or trucks. Heavy freight such as pipe and large fittings may be unloaded from the opposite side of the cars and stored in the pipe yard. This building is surmounted by a mill construction wood roof. Floors are of concrete and the office walls are plastered. Wood millwork is used throughout this building.

Three wood and stucco English cottages provide for four families. One cottage contains five rooms, one six rooms, and one double cottage contains two six-room apartments. Each apartment is provided with concrete cellar, furnace heat, plumbing, maple floors, plastered exteriors and shingle roofs. These apartments are rented to employees at cost. The rent charged is $30.00 per month per apartment exclusive of heating and light.

ORLANDO WATER WORKS AND LIGHT PLANT

At Orlando, Fla. the new station is now nearing completion. This accommodates the water filtration plant of four million gallons capacity, electrically driven centrifugal pumps of 12 million capacity augmented by four million of steam pumping capacity in another station. The generator room contains 4,000 K.W. in turbo-generators with space for 2,500 additional K.W. The boiler room contains 1500 H.P. in boilers, oil fired.

The Spanish type of architecture was used, as especially adapted to a warm climate. The boiler room is open on the rear, the boiler fronts being protected by open archways. The walls are of brick with exterior cement plaster. Roofs are supported on steel trusses with concrete slabs and composition surface. Red tile is used for sloping roofs and wall caps. The interior of the pump room is plastered. All other wall surfaces are of common brick painted. Floors are of red quarry tile.

Table 1 hereinafter shows the cost of the Orlando building including filter house and concrete filter beds; also clear water reservoir underneath the filters, but does not include cost of filter equipment or any other equipment of the plant except as stated in the tabulation.

MANISTIQUE TOWER

The opportunity was afforded at Manistique, Mich., to combine a small electric driven pumping station and a water tower. The

FIG. 6. COMBINED WATER TOWER AND PUMPING STATION, MANISTIQUE, MICHIGAN

Base of tower houses electric driven centrifugal pumps

water supply at Manistique is delivered by gravity, substantially at ground height, to the center of the town where it is pumped electrically into a steel elevated tank surmounting the pump house.

The land occupied by the pumping station was donated by the public spirited citizen upon condition that an attractive station and tower should be built. Manistique is a small city with a population about 7000. A plan was worked out which accommodated the necessary electrically driven pumps in the base of the tower, and the saving thus effected permitted enclosing the tower in an attractive envelop. The cost of the structure thus built is approximately equivalent to an uncovered steel elevated tank plus a separate building of fireproof construction.

The steel tank contains 200,000 gallons. The top is located 107 feet above the ground. It has a hemispherical bottom and is supported on the brick work 64 feet above ground by means of eight short legs horizontally braced. The tower is constructed of brick with red tapestry face brick. The trimming on the lower portion of the tower is Bedford stone and the cornice is constructed of reinforced concrete cast in place. The dome is of zinc supported on wood trusses.

The tower is octagonal outside and 16 sided inside. The brick cross-section is sufficient to support the superimposed load with a unit pressure not exceeding 175 pounds per square inch.

The sixteen sided pump room is 33 feet in inscribed diameter. It is floored with terrazzo with white enamel brick wainscot, and rock plaster walls and ceiling. A false roof is provided over the pump room with drains to catch any drip or leakage from the elevated tank. A cellar under the pump room accommodates all pipes, heating, and plumbing equipment.

The electric pumps are pressure controlled from the tank and start and stop automatically. No attendant is required in the operation of the plant except for periodical visits for inspection and oiling.

The cost of this structure complete is shown in table 1.

GARY STATION AND WATER TOWER

The Gary pumping station and water tower, although built a number of years ago is shown here as an example of what is possible in the use of concrete.

The water tower is simply a housing for a steel elevated tank supported on vertical steel legs entirely independent from the envelop. This plan was followed on account of the necessity for haste in providing a water supply for the city during the building period. The concrete envelop was added later. The shaft of the tower is of

TABLE 1

Cost of pumping station buildings

	COST	CONTRACT DATE	CUBIC FEET (THOUSANDS)†	COST PER CUBIC FEET	COST PRICE BASE*	PRESENT PRICE BASE (MARCH 1923)*	PRESENT COST PER CUBIC FEET‡
				cents			*cents*
Pumping stations:							
Des Moines, Iowa	$220,479	1920–23	810.0	27.0	178	198	30.0
Ashland, Ky	34,194	Oct. 1921	130.0	26.4	159	198	32.8
Orlando, Fla	91,800	Sept. 1922	510.0	18.0	180	198	19.8
Ironwood, Mich.							
Main station	29,155	July 1920	65.0	44.8	269	198	33.0
Sub-stations	9,644	July 1920	7.5	64.2	269	198	47.6
Manistique, Mich	71,379	Sept. 1921	140.0	51.0	156	198	65.0
LaCrosse, Wis	50,834	Nov. 1912	484.0	10.5	100	198	20.8
Prairie du Chien, Wis.	21,017	Sept. 1921	77.8	27.0	156	198	34.3
Auxiliary buildings:							
Des Moines garage	51,027	May 1922	390.0	13.1	160	198	16.2
Des Moines warehouse	18,754	May 1922	111.0	16.8	160	198	21.0
Des Moines cottages, 3 cottages, 4 families, 22 rooms	20,430	May 1922	18.0	29.2	160	198	36.0
Ironwood cottages, 2 cottages, 2 families, 12 rooms	16,900	July 1920	16.0	44.5	269	198	33.0

* Building materials United States Department of Labor.

† Each building where more than one. Contents based on outside measurements footing to average roof.

‡ As of date April 1, 1923.

reinforced concrete with a concrete dome roof. The base of all cornices and the facing on the lower one-fifth of the tower is of precast concrete applied in the usual manner where stone is used. The shaft proper is of reinforced concrete with a reinforced concrete dome roof.

FIG. 7. WATER TOWER AT GARY, INDIANA

The pumping station has concrete foundations. The pump room is depressed below the ground level and is lined with white enamel brick. Above grade walls are of brick with buff pressed brick interior face, and precast concrete enterior face. The exterior face blocks are of two colors, gray and dull red.

ASHLAND

The Ashland, Ky., plant exemplifies construction for a small city. It includes an electric driven pumping station with gasoline reserve pump; also a water filtration plant. Construction throughout is entirely fireproof and of good appearance, but no extra money was spent for the sake of appearance.

The entrance to the plant as indicated in figure 8 is through the operating floor of the filtration plant. The filter beds produce the terrace effect indicated in the picture.

Upon the Ohio River the intake problem is important on account of the extreme variation between high water and low water. The low lift pumps are located in a pit 26 feet in diameter and 43 feet deep. They consist of two motor driven centrifugals and one high speed gas engine centrifugal cash $2\frac{1}{2}$ m. g. d. against 65 feet head. Three pumps of the same kind and capacity operate against 275 feet head when pumping to the city. These pumps and the filters are installed on the roof of the clear well.

The filtration plant consists of four beds, total capacity, $2\frac{2}{3}$ m. g. d. High velocity of wash is used from a 35,000 gallon steel wash tank set on the roof of the pump pit.

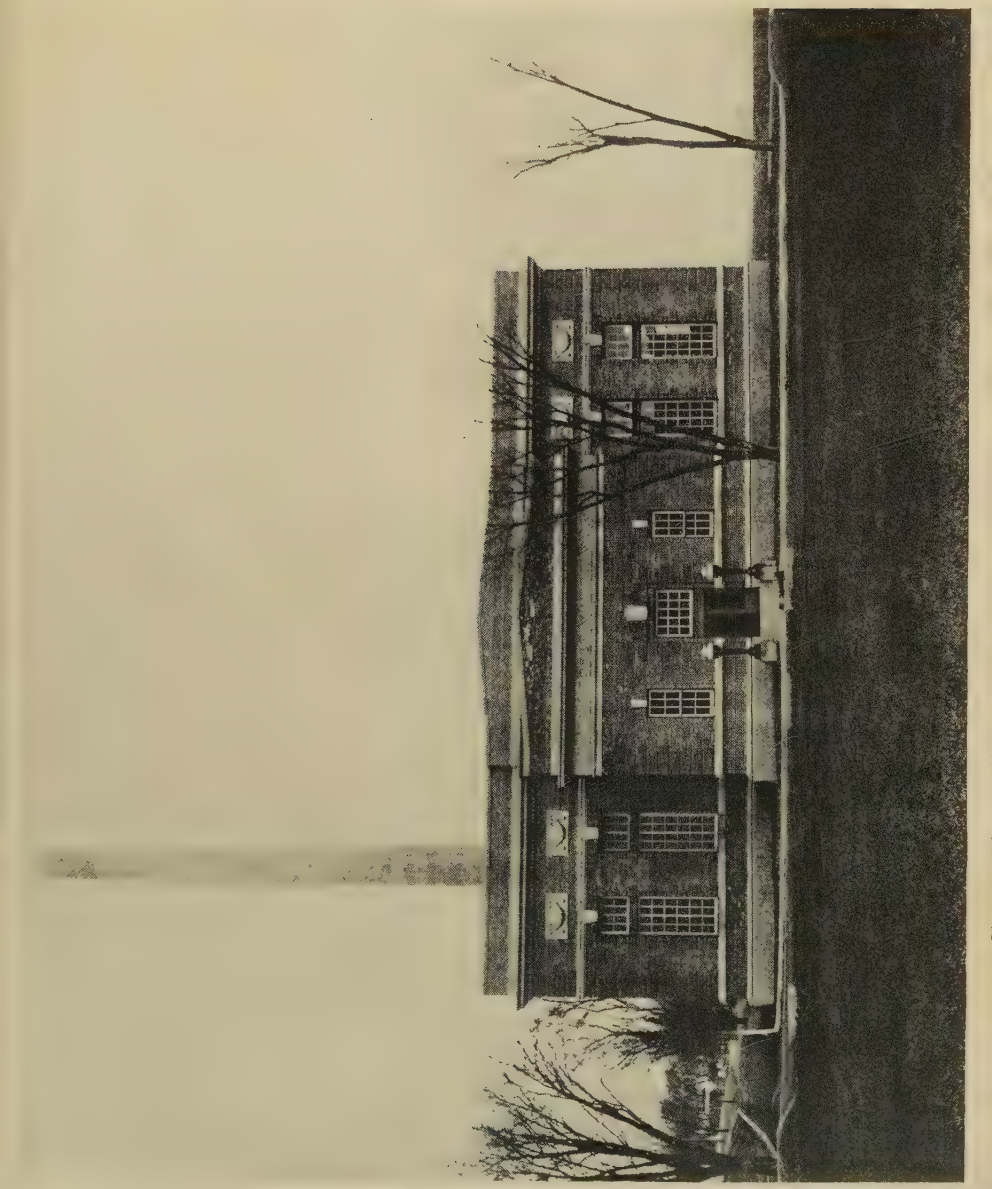
IRONWOOD, MICHIGAN

This plant develops a ground water supply from driven wells and pumps it against a head of 650 feet through a four mile pipe line of 16 inch diameter. The water is developed from three shallow well groups, each sub-station containing a 2 m.g.d pump. The main pumping station contains two three million gallon electric driven centrifugals and one and one-half million gallon high speed gas engine driven centrifugal. One gasoline driven centrifugal is also installed for reserve low lift pumping.

The buildings connected with the Ironwood Water Works are all constructed from boulders picked up on the water works lot. The saving thus effected as compared to brick was nominal, but it is believed that these building present better appearance than would brick structures in the locality where built.

The main pump house has walls of boulder stone plastered inside on metal lath and painted, floors of concrete painted, and the roof is slate on wood with matched and beaded ceiling oiled, and exposing steel trusses. Three similar sub-pumping stations were built and as

FIG. 8. ASHLAND, KENTUCKY PUMPING STATION AND FILTRATION PLANT



the plant is located some distance from habitation, it was necessary to construct two six-room dwellings also built of boulder stone.

PRAIRIE DU CHIEN, WISCONSIN

This plant represents the practicabilities in a small town where the funds available for water works construction were quite limited. This pumping plant consists of a concrete pit 45 feet inside diameter by 24 feet deep surmounted by a mill construction wooden roof with a small brick building attached to the pit at the ground level for office and shop purposes.

This plant is electrically operated. Water is sucked directly from four driven wells immediately outside the pit wall and discharged into the pipe system which is connected to an elevated reservoir on the adjoining bluffs. The pumping installation consists of one motor driven centrifugal 500 G.M., 340 feet head, one 600 G. M. high speed gasoline engine centrifugal, and one 600 G.M. motor driven triplex pump moved from an old pumping station. Space is provided for a fourth pump at some time in the future.

All foundations are of reinforced concrete. The superstructure and the parapet around pumping pit is common brick with moderate priced face brick. All sills, lintels, and caps are built of precast concrete. All roofs are of wood construction. The composition roof covering of the pit is concealed by the brick. The roof of the office and shop structure is finished with cement interlocking tile. Concrete floors are used throughout. Interior walls of brick are painted.

COST OF PUMPING STATIONS

The cost of the pumping stations that have been described and several others are shown in table 1. As the prices of labor and material have fluctuated quite materially during the period in which these stations were built there is shown in the table the date of the contract, the price basis at the time and the price basis at the present time. The table also shows the cubic foot cost of the stations as of the time when let and as of the present time. In computing cubic foot cost the contents of the building have been figured based on outside measurements and taking the height from the footing level to the average outside surface of the roof for each part of the building.

The tabulated price base is the average cost of building materials as published by the United States Department of Labor. This re-

fers to the average prices of 1913 as 100. The use of this price base presupposes a fluctuation in labor equal to the fluctuation in material price. The price of labor generally fluctuates less than the price of material. However, it is true that the efficiency of labor enters into contract cost and it is generally true that, when materials

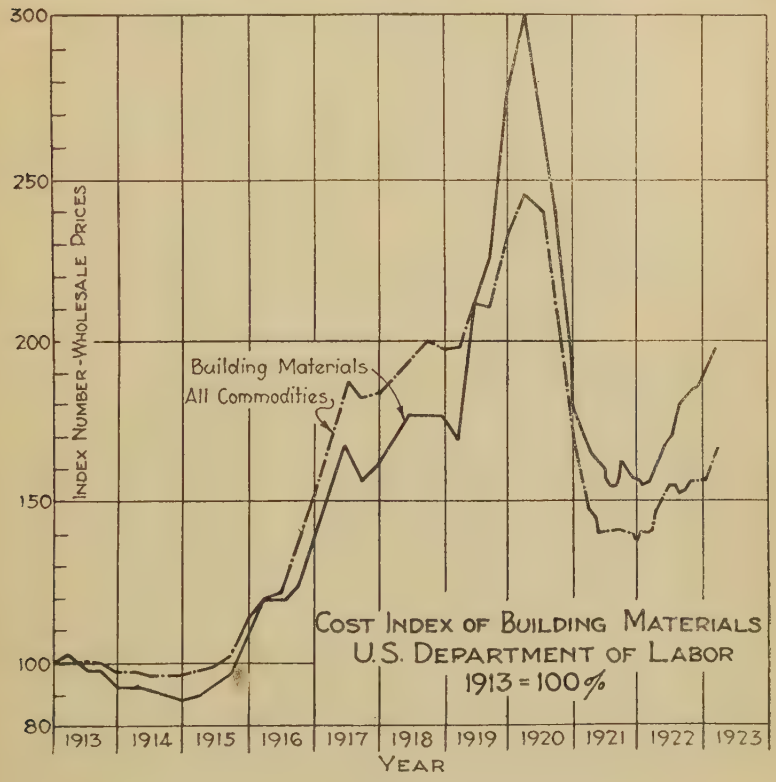


FIG. 10

are high, labor is scarce and its efficiency decreases, therefore tending to make labor cost more nearly fluctuate with the prices of materials. Apparently the assumption made regarding labor does not seriously affect the comparisons of cost for the unit prices appear to line up very well in the comparison of buildings as noted in figure 10.

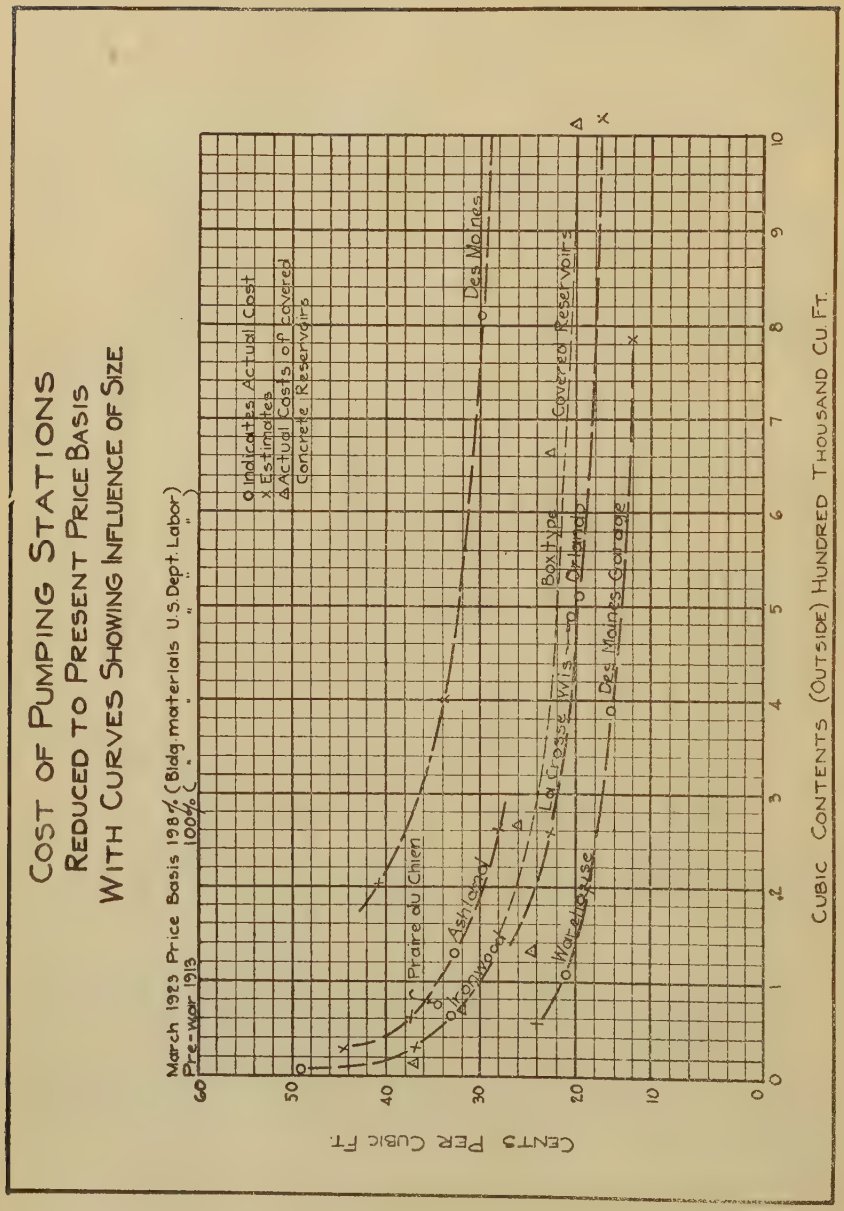

COST OF PUMPING STATIONS
REDUCED TO PRESENT PRICE BASIS
WITH CURVES SHOWING INFLUENCE OF SIZE
March 1923 Price Basis 198%
Pre-war 1913 100%
(Bldg. materials U.S. Dept. Labor)
o Indicates Actual Cost
x Estimates
Δ Actual Costs of Covered Concrete Reservoirs
Prairie du Chien
Ashland
Rhinelander
Waterloo
La Crosse, Wis.
Box type
Orlando
Covered Reservoirs
Des Moines
Des Moines Garage
CENTS PER CUBIC FT.
CUBIC CONTENTS (OUTSIDE) HUNDRED THOUSAND CU. FT.

FIG. 11

COMPARISON OF COSTS

In comparing the cost of buildings there are innumerable factors that might be considered. Pumping stations, however, are generally similar in type and vary principally in dimensions and in the degree of finish.

Figure 11 shows diagrammatically the contract price per cubic foot reduced to the present price basis and platted with reference to the cubic contents of the buildings. On this diagram a line has been drawn through each contract price which represents the approximate variation in cost for that particular type of building if increased or decreased in horizontal dimensions and hence cubic contents. It will be noted that in a number of cases these lines covering contracts for similar buildings, large and small, merge into one another. These price lines have been computed on the theory that the costs of roofs and floors vary directly as to area and that the costs of walls increase 43 per cent in doubling the area or decrease 14 per cent when the area is cut in half. These proportions hold only for perfect squares but the difference is small for an ordinary rectangular building. Miscellaneous details such as plumbing and heating are considered to vary directly with cubic contents. Upon the above basis the cost per cubic foot of an ordinary pumping station is decreased about 14 per cent in doubling its contents and it is increased about 13 per cent when its contents are cut in half.

It has been noted that the cost of box type reinforced concrete reservoirs follows closely the cost of moderate priced buildings. As the reservoir structures often accompany the pumping station the unit costs of a number of reservoirs are platted upon the diagram varying in size from large to quite small. These reservoirs are all of the same type. The prices indicated are based on cubic feet of water contained and include all costs except pipe connections.

ARCHITECTURAL COÖPERATION

It would be well if all engineers would utilize the services of an architect in the planning of conspicuous engineering works. A good architect possesses a knowledge of orderly arrangement, and the selection and grouping of materials, not possessed by most engineers. On many classes of structure the architect should be and is the master builder, and the engineer is properly a subordinate. Upon such special structures as water works buildings, the engineer must be the

master builder, but he is wise if he utilizes fully the services of one skilled in architectural design. This must be done by coöperation, the engineering plans and the architectural plans should be worked out together step by step, as a unit.

The water works manager should not ignore public approval relating to his work and his plant. Self-respect engenders respect from others. Capable operators say that employees take better care of their machinery and are more contented when working in attractive surroundings. A good plant is an important element of good service. The time has come when water works designers can safely plan for the future and build for permanence.

LEAKAGE AND UNACCOUNTED FOR WATER[1]

By J. N. Chester and E. E. Bankson[2]

PURPOSE AND GENERAL IMPRESSION

The intention of this paper is to open the discussion on the subject by recalling conclusions from other discussions and by relating some experiences in this connection. Our feeling that the subject is worthy of discussion is based on our experience, which points to a wide variation in the minds of water works men generally as to the actual or permissible amount of unaccounted for water chargeable to different divisions of the system.

In Engineering Record, February, 1912, we are informed that Mr. Bradbury mailed a questionnaire relating to leakage from water mains to sixty-six water works superintendents of Ohio. Twelve of those replying had no views on the subject of permissible leakage; another considered 500 gallons permissible per mile on 6 inch pipe; one said 44 gallons; another 1 gallon; all others considered that no leakage is allowable.

General confidence in the tightness of the pipe system, Mr. Bradbury says, is probably typical of the judgment of a great majority of those having charge of this class of work, and we have found the management of certain of our large cities having no definite idea as to what figures should apply to unaccounted for water.

LOSSES AS PERCENTAGE OF PUMPAGE

While a few water works officials may think of these losses in terms of the component parts that make up the total loss, it is probable that the average superintendent would think of the quantity or percentage which represents the difference between the pumpage and the ultimate delivery, or between the inflow at source and outflow at the spigot, as indicated by the meters.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] Of the J. N. Chester Engineers, Pittsburgh, Pa.

The Committee on Meter Rates of the New England Water Works Association reported in 1916 on Waste of Unaccounted For Water. On page 458 of December issue of the Journal of the New England Water Works Association, we find the result that for twenty-nine metered systems "*the water not accounted for averaged 27 per cent of the total output,*" and on page 459 they convert that same loss into 94 gallons daily for each $\frac{5}{8}$ inch meter unit.

In the City of Pittsburgh rate case, our computations were based on a total unaccounted for water equal to 33 $\frac{1}{3}$ per cent of the pumpage, and this is the figure also used in our general practice, unless the available data applying to that particular plant will justify otherwise. Percentages from actual tests within our experience might be noted as in table 1 together with certain published figures.

TABLE 1

Total unaccounted for water

In percentage

Norfolk, Va.	38.2	Exclusive of pump slippage
Knoxville, Tenn.	37.8	Exclusive of pump slippage.
*Kensington Water Co.	29.3	Inclusive of pump slippage
*Ellwood Water Co., less than	19.0	Inclusive of pump slippage
Published figures may be quoted as follows:		
Milwaukee, Wis.	25.27	Inclusive of pump slippage
Detroit Mich.	27.5	Slippage not stated
New Bedford, Mass.	23.0	Slippage not stated

* A large percentage of the pumpage was taken by one factory.

These figures give some idea of averages, but the New England Committee states that the figure applying to the plants studied by that committee, ranges from 12 to 49 per cent. The maximum, of course, may be 100 per cent, as was the case at White Sulphur Springs, W. Va., where we were called in for a pitometer survey in connection with the 12 mile pipe line for the water supply to the Greenbrier and White Sulphur Springs Hotels. The minimum might approach zero percentage, as indicated by Mr. Bradbury in the Engineering Record of February, 1912, for Grandview Heights, Ohio, in 1911.

An arrangement was made by this village to purchase filtered water from the Columbus Water Works. After an interval of about two months, the master meter and all individual meters were read, leaving a quantity unaccounted for of 100 cubic feet, or 2.3 gallons per day per mile, although Mr. Bradbury has since stated that, for

the first two years after this system was put in operation, the quantity of water sold through individual meters exceeded the quantity recorded by the master meter (as he remembered, about 25 per cent), undoubtedly caused by slippage of the master meter.

SOURCES OF UNACCOUNTED FOR WATER

The New England Committee report on waste mentions certain sources of losses:

1. Leakage from mains in the streets.
2. Leakage from the service pipes between the mains and the meters.
3. Under-registration of meters (slippage).
4. Water used for various purposes, not registered or estimated, as, for instance, water used for flushing sewers.

And we would say that pump slippage should head this list, if it is to correspond with some of the percentages here shown.

TABLE 2

Standards for cast iron pipe leakage

ENGINEER	LOCATION	SPECIFIED PER INCH MILE	TEST RESULT PER INCH MILE
C. F. Loweth	Statement A. S. C. E.	60–80	
E. G. Bradbury	Proposed N. E. W. W. Assoc.	100	
W. D. Gerber	Statement Ill. W. S. Assoc.	167	
F. A. Barbour	Akron—86 tests	200	83.4
F. A. Barbour	Akron—38 tests	200	61.7
New York Acqueduct	Specifications	240*	
J. H. Gregory	Columbus (3.2 miles)	500+	422
Dexter Brackett	Boston (51.5 miles)		466

* Two gallons per foot of lead joint.

No attempt was made by the Committee to segregate the percentage or amount of any item of loss except to make the statement that "It is the Committee's belief that under-registration of meters forms a substantial part of the total loss in the systems where other sources are carefully watched."

Many engineers do not possess the optimism, regarding street main losses, as expressed in the forgoing statement of the New England Committee; but it is true that perfection, in leakage from street mains, may be obtained only by constant effort, careful work or rigid specifications enforced. That views on this subject differ greatly is to be seen in figures tabulated from Mr. Bradbury's paper before the New England Association in 1914 (table 2).

This leakage at time of test, however, does not tell the story for conditions after the system has been in service for perhaps twenty-five years. The general run of joints may have tightened, or closed up, and concentrated leaks may have appeared from various causes. It is these larger leaks that require the vigilance of the water works man with leak finders, geophone and pitometer and some times only a Sherlock disposition. We had a case at one of our own plants where a $1\frac{1}{4}$ inch pipe had been running full flow for many months.

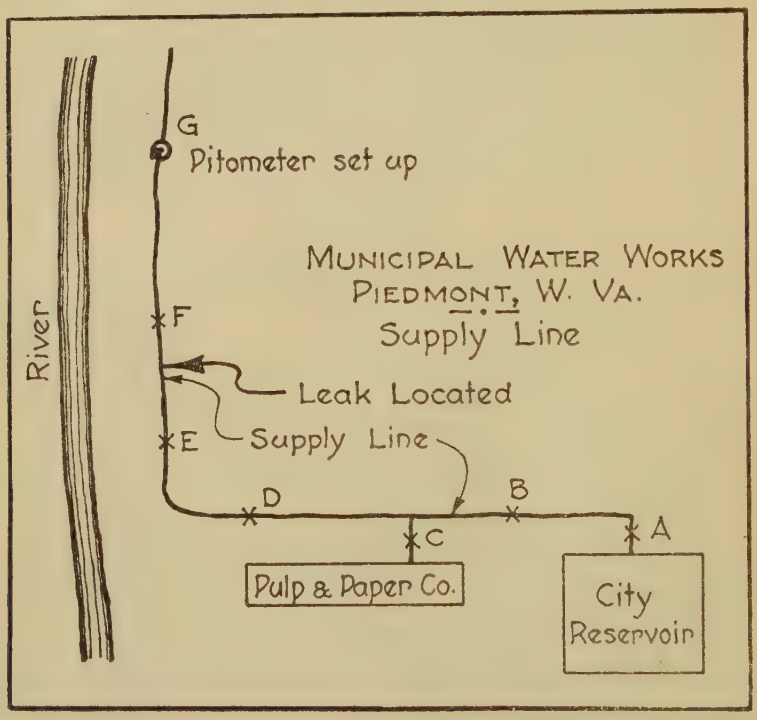


FIG. 1

We have found that a combination of the pitometer and geophone can produce most surprising results in finding leaks when in the hands of an experienced man. The writer would feel, that he had done a great service toward the progress of economy if the "bugaboo" about pitometer surveys could be dispelled. There is many a water works system where the serious leaks may be discovered in one or two nights work with the pitometer, and even the larger systems require only a correspondingly short period of time to eliminate the major troubles.

Our experience at Piedmont might be used to illustrate the principle of the most simple case which may be described by use of figure 1, where the supply line is shown coming from the gravity source to the City reservoir, with very few services on the supply line previous to its entrance to the reservoir; the service of the Pulp and Paper Company being the only one here shown.

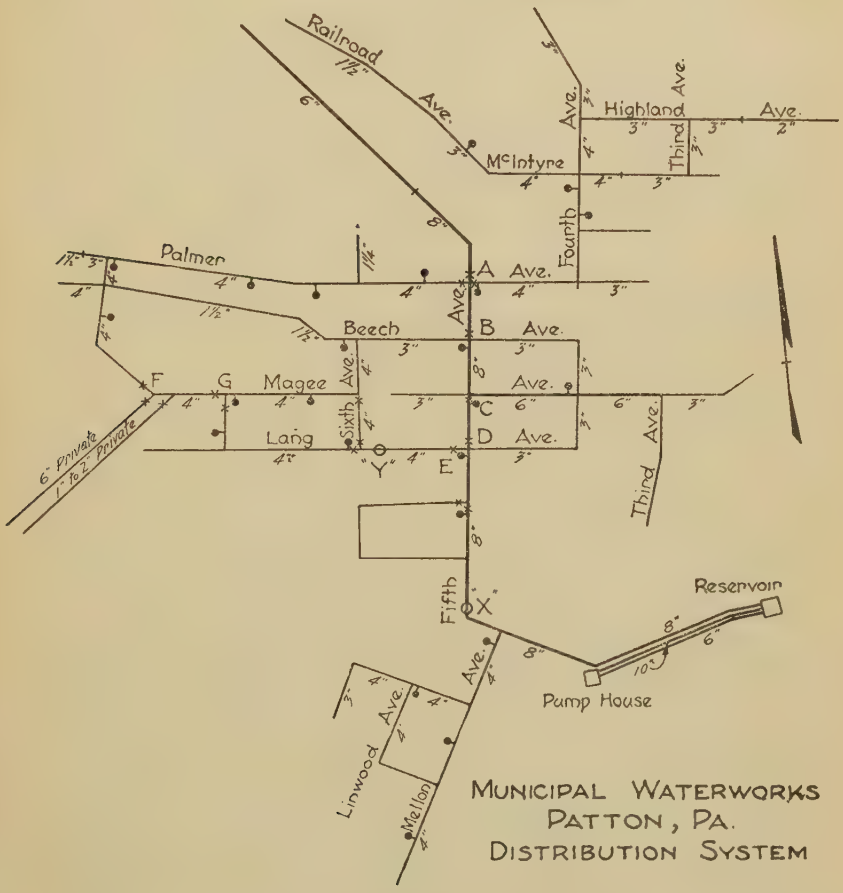


FIG. 2

For some years the Paper Company has been looked upon as the culprit who was stealing water from the City's supply lines and at some times the feeling was very bitter against them. Our suggestion that "the pitometer would produce the evidence" brought forth the response that they were positive there were no leaks in the line be-

cause they had carefully watched that feature and, from experience, they had found that the leaks always readily came to the surface any way. The approximate location of valves are shown at *A*, *B*, *C*, *D*, *E* and *F* and the pitometer set-up shown at *G*, where it was determined that practically the full supply was passing.

After the pitometer was in place and ready for operation, the valves were closed in succession from *A* to *F* at time of low flow in the night. No reduction in the flow passing the pitometer at *G* was noted until after valve *F* had been closed which means that the leakage was between *E* and *F*, and by the process of a few set-ups, with the pitometer run from *F* towards *E*, together with the use of a geophone, we finally located the leak which was creating all the trouble and which was running into the river below the ordinary flow line in such a way that it had never been detected all these years.

Our experience at Patton may be used to demonstrate the more complicated case, and this would apply to any size of system by the process of breaking that system up into parts. The distribution system for Patton is shown on figure 2.

Valves had been closed in certain parts of the system in such a way that valves *A*, *B*, *C*, *D*, *E*, *F* and *G* would serve as controlling points and with the pitometer at *X*, valves *A*, *B*, *C* and *D* were closed at the time of low flow in the night and no reduction of flow passing the pitometer was indicated until the valve *D* was closed, which meant that the leak was between *C* and *D* and was later definitely located by means of a geophone and again when valve *E* was closed a second reduction was noted. The pitometer was then set up at *Y* and the three valves at *F* were closed with no reduction in flow, but on closing *G* a decided decrease was observed, indicating that the leak was between *F* and *G*, which was also located by the geophone, in each case the leak flowing away underground unobserved. Pitometer readings for this case are shown on figure 3.

The process as described for Patton required only a few minutes for each operation of closing a series of valves and then opening them in the reverse order as a means of using the increases in flow as a check on the original decreases in flow during the operation of closing the valves.

Several examples like this could be cited where only two or three nights have been consumed in finding the serious leaks and the superintendents of some of these plants now swear by the geophone

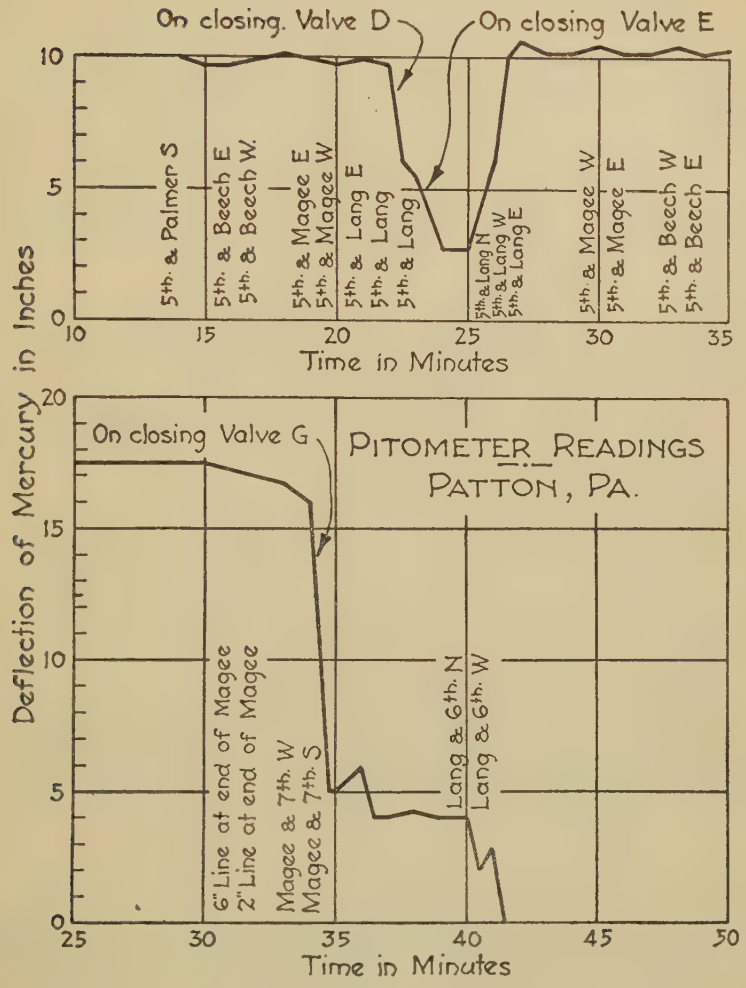


FIG. 3

and refuse to be without one, such as at Etna, Edgeworth and West Newton, Pa. Our survey at Etna, Pa., of about three nights work, discovered two or three major leaks which reduced the electric pumping bill from about $500 to $350 per month.

UNDER REGISTRATION OF METERS (OR SLIPPAGE)

The New England Committee on meter rates has stated that "there are few meters in use at the present time that will register a steady flow of as little as 100 gallons per day" and that, if at least half of the meters in service could handle the daily quantity passing at a uniform rate, instead of the fluctuating rate, it would all pass as leakage or slippage. In the Milwaukee report for 1912, appearing in the Engineering News-Record, there is assumed the figure of 3 per cent as under registration of meters, while as mentioned heretofore for Grandview Heights Ohio, Mr. Bradbury suggest 25 percent as slippage of the large meter.

We, in our own experience, have with the use of the pitometer and other means of checking and calibrating meter measurement established, to our own satisfaction, the following:

1. There are types of detector meters, especially of large diameters, that are not to be depended upon to measure consumption and so doing will contribute to the consumer from 12 to 90 per cent of the water consumed.

2. That in waters prone to form deposits and especially of a soft or mushy consistency meters may be stopped altogether and the entire consumption pass unregistered or due to the accumulations within the meter there may be an over registration from 5 to 30 per cent.

3. Frequent tests, calibration and repair of large meters increase enormously the return therefrom. It is not unusual by such means to multiply the revenue received from a consumer by two and we have had cases where as high as 500 per cent increase in return has been effected by so doing.

DISCUSSION

HENRY P. BOHMANN: I am sorry Mr. Chester did not use more recent figures. The figures he presented were for 1912, I believe. Beginning in 1912 we made an effort to control avoidable waste and started to estimate the amount of water used for domestic, industrial, and municipal use, and also show the amount of water unaccounted for. Since then we have brought this figure down as low as 11 per cent. We have assumed 5 per cent slippage of pumps and 3 per cent under-registration of meters throughout the entire period of ten years. It is true very many large meters under-register more than three per

cent, but that is an overall estimate. All large meters we test once a year. The small meters we do not test because the result would hardly justify the expense, considering the small revenue received from small meters. We figure that within the period the meter will come in the shop for some reason or other, either through frost or perhaps because registration has stopped, or for some other reason. The figures Mr. Chester presented are undoubtedly correct for that year, but we brought the figures down considerably.

JOHN N. CHESTER: How do you know you brought them down, if you assumed 5 per cent slippage.

HENRY P. BOHMANN: Because we adopted the same method all the way through of estimating the amount of water that is unmetered, the figures we show for unmetered water can be substantiated; it is not a mere guess.

JOHN N. CHESTER: Did you compile the total registration of all meters?

HENRY P. BOHMANN: Certainly.

JOHN N. CHESTER: And then you added your estimate of the unmetered water and compared that with your actual pump displacement?

HENRY P. BOHMANN: Yes sir. First, we deduct 5 per cent for slippage of pumps to show the amount of water that actually went into the distribution system and then there is the metered water.

JOHN N. CHESTER: Which you again correct with 3 per cent.

HENRY P. BOHMANN: We allow 3 per cent for under registration of meters, since everyone knows that meters do under-register.

JOHN N. CHESTER: If you had a master meter at your station and cut out pump slippage, that would make it comparable with some of the figures here?

HENRY P. BOHMANN: We cannot do that because several of our pumps discharge into one discharge main and sometimes run singly and sometimes double, and are equipped only with Venturi meter.

JOHN N. CHESTER: What is your unaccounted water when you simply equate your meter consumption, meter registration, against your master meter registration? What then is the difference?

HENRY P. BOHMANN: As I told you, we have had it down as low as 7 per cent unaccounted for.

JOHN N. CHESTER: But you first deduct those other percentages?

HENRY P. BOHMANN: First of all we deduct 5 per cent from the displacement of the plungers of the pumps to take care of slippage. We have 5 discharge mains with Venturi meters, but have only one pump that discharges into a separate discharge main, consequently it is not practical to do otherwise.

JOHN N. CHESTER: But you are talking about pump slippage; let us leave that out; you say all your discharge mains have master meters?

HENRY P. BOHMANN: Not the mains, they have a Venturi tube, with a recorder, but we have not a separate discharge main with a separate discharge recorder for each pump, that is the reason why we use the Venturi, merely as a check against plunger displacement.

JOHN N. CHESTER: You are talking about pump slippage, and I am trying to get the unrecorded water, leaving out pump slippage.

HENRY P. BOHMANN: In Chicago they estimate pump slippage at 15 per cent.

JOHN N. CHESTER: The water that passes your master meter, let it be assumed as the amount pumped; how do your small meters add up as compared with the results of your master meters?

HENRY P. BOHMANN: You have got to add to that the amount of water unmetered.

JOHN N. CHESTER: All right, do that.

HENRY P. BOHMANN: You want to eliminate the slippage entirely?

JOHN N. CHESTER: Oh, yes, I want to forget it.

HENRY P. BOHMANN: Then we will say about 15 per cent is unaccounted for, but I do not think that is fair, because there is certainly some slippage in every station, and if the stations throughout the country would have but 5 per cent, they would make a better showing than at the present time. What is the use of trying to account for something that is not going into your distribution system?

JOHN N. CHESTER: The master meters are between the pumps and the city, are they not?

HENRY P. BOHMANN: We only use our Venturi meters as a check against displacement and then we deduct 5 per cent for correction.

A. S. HOLWAY: Four years ago, we checked up our meter consumption as 44 per cent of the pumpage. We have been able to reduce the unaccounted for water to such a point that our total metered water which we sell is 79 per cent of the water which leaves the pumping station. We have found that our greatest losses come from three sources. We had some illegal consumers, we had one 8 inch illegal connection, one 3 inch connection and a 1 inch meter by-pass. We found quite a few leaking flush tanks in the sewer system, but our greatest loss was due to poorly kept up meters, and I think that that is a thing that is very frequently overlooked in most systems, and that is the greatest cause for unaccounted for water.

W. S. CRAMER: We pride ourselves that we have been for twenty years 100 per cent metered. I mean that we sell no water except through a meter; we do not allow the use of fire hydrants by contractors or any other connection except through a meter, and we have a good clay soil and the water comes to the surface; at least we think it does. We have all cast iron mains and lead services, and we pride ourselves that we should be free from leaks, but in checking

back against our meters and against our pumps, we could not get an accounting for the water through the pumps; our pumps were in fairly good condition and were tested as much as pumps could be tested by blocking the piston and testing them that way. We put a meter on our discharge, and immediately we got a perfect check, and a survey showed a loss of 740,000 gallons in twenty-four hours on a system we thought was in first class shape. Almost all the leakage was water that was going to waste through sewers. There had been an intensive sewer campaign and leaks were going through the sewers and not showing on the surface, so there are very few of you who can rest on the supposition that you have no leaks or are accounting for the water, unless you are actually going over the system and finding out whether you have those leaks. We stopped a leakage of about 20 per cent of the water pumped.

RECARBONIZATION OF SOFTENED WATER[1]

By Nicholas S. Hill, Jr.[2]

For municipal purposes it is frequently desirable to filter water as well as to soften it, and it is not uncommon in municipal plants to deliver a hard water after treatment by the lime and soda process to mechanical filters where the water is filtered in the ordinary way. Except that where softening is desirable, larger sedimentation basins are generally used and facilities must be provided for storing the lime and soda and mixing them with the water, the combined softening and filtering plant is substantially the same as the ordinary filtration plant. Where softening precedes filtration, however, difficulties arise, one of which results from the deposition of the calcium and magnesium carbonates, which are carried to the filters with the settled water, on the grains of the filter sand and in the filter piping and mains. As a result of the deposition of the carbonates on the sand grains they become heavily coated and their effective size is much increased. The experience at Columbus, Ohio, Grand Rapids, Michigan, McKeesport, Pennsylvania, and other places, indicates that the sand in the filter beds becomes so coarse as to make it inefficient at times for filtering turbid water, but this is not the only difficulty. The calcined grains cement themselves together, forming hard lumps which become quite large in size and are so hard that they have to be dug out of the filter beds in order to be broken up. This lumping of the sand prevents the wash water from breaking through the sand beds uniformly and, therefore, causes a high rate of filtration in the free parts of the filter beds. Under such conditions it is necessary to add excessive amounts of alum to remove turbidity, which increases the cost of treatment.

The presence of the carbonate of lime also interferes with the proper operation of the filter underdrains.

The ideal softened water should contain neither permanent hardness nor temporary hardness. From an operating viewpoint it should

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

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be entirely free from caustic or carbonate alkalinity, but this result is difficult, if not impossible, to achieve with the lime and soda process, and due to limitations in the accuracy of applying lime and soda solutions and the vagaries of the re-actions in water softening, caustic water is often delivered to the filtration plant from the settling basins, particularly when it is attempted to keep the hardness of the water to be softened at the lowest possible limit. On the other hand, the application of a slight excess of lime frequently insures a better degree of softening, provided the causticity produced by the introduction of an excess of lime may be subsequently removed.

A caustic water which is produced by an excess of lime hydrate, without further treatment, leads to troubles with after-precipitation and to complaints from consumers due to its objectionable taste.

Much trouble has been experienced in combined water softening and filtration plants from the presence of the carbonates of lime and magnesia and hydrate of lime in the effluent from the settling basins, and much has been written and said upon the subject.

Attempts in the past to remove the lime and magnesium carbonates have been devoted chiefly to increasing the size of the sedimentation basins by giving them a capacity equal to from ten to twenty hours detention to allow time for the re-action between the lime and bicarbonates in the water as well as time for the complete precipitation of the lime carbonate in the softened water, thereby reducing the deposits of the calcium carbonate on the grains of the filter sand and in the filter piping and mains. Such basins, however, have served as a palliative rather than a remedy, and these large basins are expensive to construct, particularly where land values are high.

Results at Columbus, Ohio, from twelve thousand determinations during the past eleven years indicate that the period of re-action between the softening chemicals and the calcium and magnesium salts is short. Mr. Charles P. Hoover, Chemist in Charge of this plant states in *The City Bulletin*, the official publication of the City of Columbus, of April 15, 1923, that 90 per cent of the re-action accomplished takes place in the mixing tanks, 3 per cent in the fifteen hours through the settling basins, and 7 per cent in passing through the filters. The average hardness of the Scioto River water at Columbus is 275 parts per million, of the water entering the settling basins 119 parts per million, at the outlet of the settling basins 113 parts per million, and of the filtered water 101 parts per million. As he states, these figures are startling because they indicate that large settling

basins are not necessary for the proper chemical re-actions at least, as has always been supposed, and certainly they are not always effective in sedimenting the lime carbonate when it is in a collodial state.

At some plants roughing filters made of excelsior or other materials have been used to remove the carbonates of lime after the water leaves the settling basins and before it passes on to the filters, but this method has not proved successful in operation.

The first investigations towards working out a practical solution of the difficulties resulting from the presence of lime carbonate in the effluent of the settling basins were made by Mr. Charles P. Hoover at the Columbus plant, so far as I can recall at this writing. The first method which suggested itself to him was to carbonate the water with CO_2, and he experimented with a number of ways by which carbon dioxide might be produced, among which were:

1. Burning the lime sludge from the settling basins, producing lime and CO_2.
2. Treating the lime sludge from the settling basins with sulphuric acid, producing calcium sulphate and CO_2.
3. Calcining sodium bicarbonate, producing sodium carbonate and CO_2.
4. Treating soda ash with sulphuric acid, producing sulphate and CO_2; then roasting the sodium sulphate in a furnace with slack coal and limestone, producing sodium carbonate, which could be used in softening.

By carbonating the water the insoluble carbonates are converted into the soluble bicarbonates. If the water is caustic the CO_2 will re-act with the caustic or hydrate of lime, producing soluble bicarbonates of lime. In other words, by using CO_2 the normal carbonate alkalinity and the caustic alkalinity are converted to bicarbonate alkalinity in solution and there is no reduction in the hardness of the water which leaves the settling basin.

It would be a desirable thing if an inexpensive and easily handled re-agent could be found which would not only convert the carbonates and hydrates into soluble bicarbonates but precipitate all, or even a large portion, of these as well, for then not only would the stabilizing effects desired be accomplished but additional softening as well. Various re-agents have been tried for this purpose. Boric, oxalic, tartaric and phosphoric acid were experimented with at the Columbus plant, and there the final conclusion reached was that as a finishing treatment to lime-softened water phosphoric acid was the best and most economical.

The advantages of using a re-agent of this kind as compared with carbon dioxide are obvious, but the method is expensive and difficult to handle. It was found, however, that when enough phosphoric acid was added to lime-softened water to combine with the caustic alkalinity, and with one-half the normal carbonate of calcium and magnesium, a re-action resulted which produced tri-calcium phosphate, which is insoluble and readily settled from the water and CO_2, which carbonated the remaining quantity of normal carbonates. By this process half of the carbonates are removed, thus reducing the hardness of the water. The balance of the carbonates are carbonated, thus producing a water that is stable.

The first application of carbon dioxide gas to water, which is generated from the burning of coke, subsequent to treatment by the lime and soda softening process, so far as the author knows, was at Owensboro, Kentucky, some years ago. (For description of this plant see this JOURNAL, 1912, page 203). The apparatus employed, however, was very crude and although the results were reported as satisfactory, the use of this gas to eliminate or nullify the ill effects produced by the carbonates of lime and magnesium and lime hydrate seems to have been entirely overlooked.

Nowhere that the author knows of has any attempt been made, prior to the installation of the carbonating plant at Defiance, to provide a workable and controllable means of applying CO_2 to the effluent from the settling basins for the purpose of converting the carbonates of lime and magnesium and lime hydrate in the softened water into the bicarbonates of lime and magnesium.

It is not my purpose to describe the Defiance, Ohio water treatment plant in detail, as a description of it has already been published in this JOURNAL, 1920, page 440.

The average quality of the raw Maumee River water, based upon the average of daily analyses at the Napoleon and Toledo filtration plants as well as analyses at Defiance, and of the softened water at Defiance for the year 1922, is as follows:

	RAW WATER	FILTERED WATER
	p.p.m.	*p.p.m.*
Turbidity	200	0
Color	40	8
Total hardness	230	125
Alkalinity	170	52
Incrustants	60	73
Calcium hardness	172	70
Magnesium hardness	58	55
Bacteria per cubic centimeter at 37°C	400	

From September 1, 1920 to January 15, 1922 both lime and soda were used in the treatment, but since the latter date only lime has been used. In other words, since January 15, 1922, there has been no attempt to reduce the incrustants or permanent hardness but to reduce only the temporary or carbonate hardness. This method of operation has been followed in the interest of economy as it has been found that the removal of the temporary hardness produces a water which is locally satisfactory and that the total hardness may be maintained at an average of about 125 parts per million.

While the above characteristics present the average quality of raw water to be expected, the variations are extreme. Turbidity at times may be as high as 4000. Total hardness is sometimes as high as 350, and the bacterial count at 37°C. reaches several thousand. In view of the variable quality of the water and the constant variation in the amount of chemicals used, it was necessary to design the carbonating plant so that the amount of CO_2 applied could be regulated and a CO_2 recorder is a part of the equipment of the plant. The amount of coke required, however, to treat a million gallons of water at Defiance is less than 100 pounds, so that the cost is nominal, and it was found that it would not be necessary to prevent the application of some excess CO_2.

According to Mr. H. T. Campion, Superintendent at the Defiance plant, the added cost of the carbon dioxide treatment does not exceed $1.88 per million gallons under the present intermittent method of operating the plant, which naturally increases the amount of coke required per million gallons as it is impossible to prevent the generation of gas in the retort when the softening plant is shut down.

In operation it has been found possible to control the application of CO_2 so that no gas escapes from the surface of the water entering the chamber and hence there is no waste of gas. The amount of CO_2 applied is regulated, so that when the water leaves the plant it has no more than three to five parts per million of free carbonic acid.

For the benefit of those who have not read the description of the plant above referred to, I would say that the carbonating plant at Defiance consists of a retort in which coke, sometimes with an admixture of a small amount of limestone, is burned, giving off CO_2. A seventy-two hour coke has been used for generating the CO_2. This material burns slowly, holds its fire well and has a low sulphur content. An eight hour coke was tried but did not prove as successful as the seventy-two hour coke. The eight hour coke contained at times unburned tar and it is possible that the use of this material caused slight phenol odors in the carbonated water at times. After the gas is generated in the retort it is mixed with air introduced through a valve which opens to the atmosphere and is placed on the pipe which conducts the CO_2 from the retort to the scrubber. The amount of air admitted is controlled at this point and is adjusted so as to regulate the quantity of CO_2 to be applied to the water. The admixture of air and CO_2 gas then passes through the scrubber. The admixture enters the bottom of the scrubber and the water is fed to it at the top. This removes the impurities from the products of combustion. The admixture of gas and air passes from the scrubber through the dryer and from there goes to a chamber, which, for want of a better name, I have called the carbonating chamber. A blower or compressor is installed adjacent to the retort which sucks the air and gas from the retort through the scrubber and drier, and forces the mixture through a 2 inch fibre pipe line to the carbonating chamber. There the admixture of air and CO_2 is delivered to an annular space beneath filtros plates and is allowed to pass up through the filtros plates and the water. When the CO_2 mingles with the water the normal insoluble calcium carbonate is converted into soluble calcium bicarbonate and the calcium hydrate is also converted into soluble calcium bicarbonate. Insoluble magnesium hydrate is also converted into soluble magnesium bicarbonate.

There is a continuous flow of water through the carbonating chamber, the period of detention being about one hour. A series of baffles is provided in this chamber so that the water passes up and down in its travels through the container.

The percentage of carbon dioxide in the mixture of gases applied to the water is not high, varying from 3 to 10 per cent of the total mixture of air and gas to meet the condition of the settled water, the phenolphthalein alkalinity of which varies appreciably. No variation is made in the volume of air and CO_2 sent to the carbonating chamber, but variations in the amount of CO_2 applied are effected by changing the mixture of air and gas. The compressor or blower is run at a uniform speed all the time and a CO_2 recorder has been installed adjacent to the compressor which shows at any time the percentage of CO_2 in the admixture of air and gas delivered to the carbonating chamber.

The regulation of the amount of CO_2 gas to be applied at any time is effected by making hourly tests of water leaving the carbonating chamber with phenolphthalein. If the tests show too great an excess of CO_2 the operator is instructed to reduce the percentage of CO_2 in the mixture of air and gas as indicated by the CO_2 recorder, and if there is no excess of CO_2 the operator is instructed to increase the percentage in the admixture.

From time to time in the past troubles from odors in the Maumee River water have been experienced when the river is low or ice bound, and these odors caused a prejudice to the water by the consumer. The dissolved oxygen in the river water at times is very low. It has been shown above that the percentage of carbon dioxide in the admixture of air and gas delivered to the carbonating chamber varies between 3 and 10 per cent, so that a large proportion of the admixture is air. The aeration which is offered by the passage of the air through the water in the carbonating chamber has a beneficial effect during the occurrence of odors in the raw water. Tests for dissolved oxygen in the raw water and as it leaves the carbonating chamber show a material increase in saturation in the carbonated water at times when the oxygen content of the raw water is low.

At the time the carbonating chamber was designed the author had no precedent by which to go and little definite knowledge of the effect of temperature and other agencies upon the time required for the re-actions desired, and as a precautionary step was very careful to make this chamber sufficiently large to allow ample time for the completion of all chemical re-actions. As a result of the operation of this plant, however, and the promptness with which the re-actions take place, he would install a smaller and simpler carbonating chamber where there was no necessity for combining aeration with carbonation.

One of the interesting features of the plant is that in designing the carbonating chamber precaution was taken for the removal of sludge due to the precipitation of the calcium carbonate by the first

TABLE 1

Results of analyses of water from water treatment plant at Defiance, Ohio

CONSTITUENTS	INLET, SETTLING BASIN		OUTLET, SETTLING BASIN		OUTLET, CARBONATING CHAMBER—CARBONATED WATER		OUTLET, FILTERS—FILTERED WATER	
	Sample 8754 10-23-22	Sample 9421 4-10-23	Sample 8755 10-23-22	Sample 9422 4-10-23	Sample 8756 10-23-22	Sample 9423 4-10-23	Sample 8757 10-23-22	Sample 9424 4-10-23
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Turbidity	48	375	12	13	1	6	0	0
Color	24	43	6	14	6	10	9	8
Total solids	419	687	238	241	241	244	242	250
Suspended solids	65	367	19	9				
Solids in solution	354	320	219	232				
Iron							0.05	0.05
Total hardness as calcium carbonate ($CaCO_3$)	247	218	99	117	120	126	121	129
Lime (Ca) expressed as $CaCO_3$	153	165	67	105	84	111	79	106
Magnesium (Mg) expressed as $CaCO_3$ (by difference)	94	53	32	12	36	15	48	23
Caustic alkalinity expressed as $CaCO_3$	0	0	20	2	0	0	0	0
Normal carbonate alkalinity $CaCO_3$	14	0	16	32	0	0	0	0
Bicarbonate alkalinity $Ca(HCO_3)_2$ expressed as $CaCO_3$	172	163	0	0	50	33	47	35
Free carbonic acid (CO_2)	0	5.3	0	0	0	5.1	1.3	0
pH	8.1	7.7	9.8	9.5	7.85	7.1	7.65	7.8
Chlorides (Cl)	16.9	5.3	16.3	6.5	16.0	6.2	16.0	7.7
Sulphates (SO_3)	66	56	77	73	79	71	75	76

re-action in the conversion of calcium hydrate to calcium bicarbonate when the CO_2 is applied to water which contains caustic lime. In actual operation, however, it has been found that there is practically no deposition of sludge as the re-action takes place so rapidly that

the end product of soluble bicarbonate of lime is at once produced. The provision for the removal of sludge according to the experience at Defiance is, therefore, not necessary.

The author regrets that he is not able to present the results of systematic analyses made to cover a long period of time so that good average results could be presented. Reports of the daily operation of the plant, however, have shown that it has proved efficient and economical.

Table 1 gives the results of analyses made in the author's laboratory of samples taken at different points in the softening and filtration process. It shows that the caustic alkalinity and normal carbonate alkalinity, which are present at the outlet of the settling basin, are entirely removed in the carbonating chamber and are converted into soluble bicarbonate alkalinity.

Further reference to this table also indicates that the alkalinity after leaving the carbonating chamber is somewhat higher than before it enters it. It would be natural to expect a reduction of alkalinity in the carbonating chamber as the second application of aluminum sulphate is made at this point. Taking the normal reduction due to the second application of sulphate of aluminum into consideration there is an appreciable increase in the alkalinity of the water after it leaves the settling basin and passes through the carbonating chamber. The increase in alkalinity probably accounts for the increase in total hardness, although the number of analyses available is not sufficient to make this statement definite. In fact, it would take a long run of analyses for the purpose of getting proper averages to enable one to draw deductions as to just what changes take place. The important thing is that normal calcium carbonate and magnesium hydrate are stabilized by conversion into the soluble bicarbonate hardness.

The only disadvantage of carbonating the water is that there is no reduction in the total hardness, and probably a slight increase in total hardness, after the water leaves the settling basin, but when it is remembered that it not only removes the lime carbonate which causes so many operating troubles in filter beds, but also the causticity, thereby enabling the operator to apply an excess of lime when it is advisable or economical to do so, its advantages outweigh its disadvantages. Its simplicity, easy control and small cost weigh heavily against the adoption of other methods which will somewhat reduce the hardness of the water after it leaves the settling basin but which involve appreciable expense and difficulty in application.

It has been found that, by regulating the CO_2 applied to the carbonating chamber, so that at all times there is some CO_2 present in the carbonated water, the flat taste which is noticeable in most lime-softened waters has been removed.

By the use of the process it is possible to reduce the period of detention in the sedimentation basin from that in the ordinary settling basin of from ten to fifteen to six hours or less.

It is estimated that the cost of the CO_2 plant, including fixed charges and operating expenses, does not exceed the interest on the cost of larger basins which would have to be built if this process is not installed, and the experience at Defiance has indicated that the carbonating process is far more effective than the introduction of larger basins.

The re-actions which occur in the carbonating chamber may be stated as follows: When lime hydrate in the settled water is treated with carbon dioxide gas the lime hydrate is converted to calcium carbonate and then a further re-action between the calcium carbonate and carbon dioxide converts the calcium carbonate into calcium bicarbonate. The re-actions taking place in the carbonating chamber may be expressed as follows:

Calcium hydrate	+	Carbon dioxide	=	Calcium carbonate	+	Water
$Ca(OH)_2$	+	CO_2	=	$CaO \cdot CO_2$ ($CaCO_3$)	+	H_2O

Calcium carbonate	+	Carbon dioxide	+	Water	=	Calcium bicarbonate
$CaOCO_2$	+	CO_2	+	H_2O	=	$CaO_2\ CO_2H_2O$ ($Ca(HCO_3)_2$)

Magnesium carbonate is much more soluble in water than is calcium carbonate and the precipitate of magnesium which goes over from the settling basins is usually in the form of magnesium hydrate. The re-action which takes place in the carbonating chamber so far as the magnesium salts are concerned may be expressed as follows:

Magnesium hydrate	+	Carbon dioxide	=	Magnesium carbonate	+	Water
$Mg\ (OH)_2$	+	CO_2	=	$MgO \cdot CO_2$ $MgCO_3$	+	H_2O

Magnesium carbonate	+	Carbon dioxide	+	Water	=	Magnesium bicarbonate
$MgO \cdot CO_2$	+	CO_2	+	H_2O	=	$MgO \cdot 2CO_2 \cdot H_2O$ $Mg(HCO_3)_2$

The operations of the plant, which has now been in service about twenty-one months, have been watched by the author with some interest. Samples of the sand from the filter beds have been collected

and brought to his laboratory on two occasions, in October of 1922 after the plant had been in operation a little over a year, and in April of 1923, when the plant had been in operation about twenty-one months. Mechanical and chemical analyses were made of the original sand used in the filters as well as of samples from each filter bed for the purpose of ascertaining whether there was any appreciable change in the effective size and uniformity coefficient of the sand as a result of actual operations, as well as to ascertain the quality of the coating on the sand grains if they had become coated.

The results of the mechanical analyses of the original sand as compared with samples taken from each of the filter beds in October of 1922 and in April of 1923 compared with similar analyses of sand taken from the Grand Rapids plant after service for about the same period of time are given in table 2. The samples taken on October,

TABLE 2

Mechanical analysis of sand samples

	DEFIANCE ORIGINAL SAND—AVERAGE THREE SAMPLES, 5-16-21	DEFIANCE FILTER BED SAND—AVERAGE FOUR SAMPLES, 10-11-22, IN USE 15 MONTHS	DEFIANCE FILTER BED SAND—AVERAGE FOUR SAMPLES, 4-11-23 IN USE 21 MONTHS	GRAND RAPIDS ORIGINAL SAND	GRAND RAPIDS, IN USE 2 MONTHS	GRAND RAPIDS, IN USE 22 MONTHS
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Effective size.....	0.43	0.49	0.49	0.35	0.42	0.51
60 per cent finer than...	0.63	0.62	0.62			
Uniformity coefficient...	1.51	1.27	1.26	1.25	1.33	1.22

1922 after the Defiance plant had been in operation a little over a year indicate that the effective size of the sand had increased from an average of 0.43 to 0.49 and that the uniformity coefficient had dropped from an average of 1.51 to 1.27. The increase in size at Grand Rapids for a similar period was from 0.35 to 0.42 and in the uniformity coefficient from 1.25 to 1.33.

The increase in effective size and reduction in uniformity coefficient at Defiance is in the judgment of the author no greater than would be expected from the continued washing of the filters in an ordinary filtration plant.

Mechanical analyses made on the samples collected at the Defiance filter plant in April, 1923 show an effective size of 0.49 as compared with 0.49 for the samples from the Defiance filter beds taken in October, 1922, or exactly the same.

The effective size of the sand from the Grand Rapids plant taken in August, 1914, after it had been in operation about twenty-two months, had increased from 0.35 to 0.51, an increase of 16 points as compared with 6 points for the same period at Defiance.

The uniformity coefficient of the samples collected at Defiance in April, 1923 was 1.26 as compared with 1.27 for the October, 1922 samples.

These results compared with the Grand Rapids results are interesting and seem to indicate that the Defiance sand had reached its natural grading as a result of the continued washing in October, 1922, and no appreciable change has occurred in the last six months either in uniformity coefficient or effective size.

Further to ascertain definitely whether the accretions on the filter bed sand were appreciable, 100 grams of this sand were treated with 1-1 cold hydrochloric acid. The acid was then filtered off, the sand washed, dried, and a mechanical analysis of it then made for comparison with the sand as it was removed from the filter beds, after twenty-one months use, as well as with the original sand. The comparison follows:

	UNTREATED FILTER BED SAND	TREATED FILTER BED SAND	ORIGINAL SAND
(1)	(2)	(3)	(4)
Effective size	0.49	0.48	0.43
60 per cent finer than	0.62	0.62	0.63
Uniformity coefficient	1.26	1.29	1.51

This test confirms the author's belief that the slight increase in the effective size and reduction of the uniformity coefficient of the used sand are due to the grading which follows the continued washing of sand in filter beds.

While there was no visible coating on the surface of the sand grains taken from the filter beds, the author thought it was desirable to make a chemical analysis to ascertain if possible what the nature of the coating was, if any. Twenty gram portions of the filter bed sand were treated with 1-1 hydrochloric acid in the cold. The sand was then filtered off and washed with water. This treatment has no effect on the sand itself, but dissolves practically all the aluminum, calcium or magnesium compounds that might stick to the surface of the sand grains. Samples of the original sand before it was used in the filter beds were taken as a control and treated in the same way.

The filtrate was evaporated to dryness in platinum dishes and the residue weighed. It was ignited and weighed again. It was then dissolved in acid and a chemical analysis made to determine the composition of the fixed residue of all the samples. The results of these analyses are shown in table 3.

The samples of the original sand showed no effervescence when the hydrochloric acid was added, and only one of the sands removed from the filter beds showed effervescence, and in this case it was only in a spot or two. This indicated how free from carbonates the sand from the filter beds was.

The total acid soluble residue as dissolved by the 1-1 hydrochloric acid in the four samples of filter bed sand which were treated varied

TABLE 3

Chemical analysis of sand from Defiance, Ohio, filtration plant (data in per cent)

CONSTITUENTS	ORIGINAL SAND, SAMPLE NO. 292	FILTER NO. 1, SAMPLE NO. 288	FILTER NO. 2, SAMPLE NO. 289	FILTER NO. 3, SAMPLE NO. 290	FILTER NO. 4, SAMPLE NO. 291	AVERAGE, NO. 288 TO NO. 291
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total residue	0.038	0.87	0.78	0.59	0.65	0.72
Organic and volatile	0.025	0.42	0.40	0.31	0.34	0.37
Fixed residue	0.013	0.45	0.38	0.28	0.31	0.35
SiO_2	0.002	0.115	0.085	0.070	0.062	0.083
Fe_2O_3 and Al_2O_3	0.005	0.194	0.142	0.105	0.134	0.144
CaO	0.002	0.028	0.043	0.017	0.035	0.031
MgO	0.001	0.009	0.007	0.008	0.009	0.008
Undetermined	0.003	0.104	0.103	0.080	0.070	0.084

from 0.59 to 0.87 per cent by weight of the sample of the sand taken, with an average of 0.72 per cent. The average fixed residue on the filter sample was 0.35 per cent. The control or the original sand showed a total acid soluble residue of 0.038 and a fixed residue of 0.013 per cent.

Similar analyses of sand taken from the Grand Rapids filter bed after twenty-two months of use as compared with twenty-one months of use at Defiance showed an increase in the acid soluble residue of from 6.5 in the original sand to 45.2 per cent in the filter bed sand, an increase of 38.7 as compared with an increase for the same period of 0.7 per cent at Defiance.

The results of the analyses of the fixed residue derived from the filter bed sands showed that of the 0.35 per cent fixed residue 0.1 per cent was silica, expressed as percentage of the weight of the sample

of sand originally taken, 0.15 was iron and aluminum oxides, most of which was aluminum oxide, and only 0.03 lime oxide and 0.01 magnesium oxide, leaving 0.1 per cent undetermined.

From this it is seen that what coating there is is largely organic and volatile matter and that of the mineral matter the largest proportion is aluminum oxide, coming probably from the floc of the aluminum hydrate which adheres to the sand grains. The calcium and magnesium oxides in this coating, as shown, are practically nil.

In considering the effects of carbonates on the sand it is well to remember that at numerous times during the first months of operation of the carbonating plant at Defiance carbonation was discontinued in order to make adjustments and repairs to the apparatus before it was finally shaken down to an operable condition.

In the autumn of 1922 it was discovered that when the meters were opened there was a dirty white deposit in the frost case and a green deposit in the gear case. One of these meters was forwarded to the author's laboratory in New York. These deposits were scraped out and an analysis was made of each, which is given below:

	SAMPLE NO. 259, FROST CASE DEPOSIT	SAMPLE NO. 260, GEAR CASE DEPOSIT
(1)	(2)	(3)
	per cent	*per cent*
Moisture at 105°C	4.1	3.9
Loss on ignition	25.24	33.82
Insoluble in acid	30.24*	21.54*
Soluble portion:		
Silica (SiO_2)	1.86	0.40
Combined oxides, mostly Fe_2O_3 and Al_2O_3	7.54	3.32
Calcium oxide (CaO)	0.56	1.14
Magnesium oxide (MgO)	0.44	0.12
Copper oxide (CuO)	None	34.85
Zinc oxide (ZnO)	27.32	None
Lead oxide (PbO)	None	0.44
Sulphate (SO_3)	2.16	0.98
Total	99.46	100.51
Carbonates	Present	Present

* This material, insoluble in acids, was subsequently decomposed with hydrofluoric acid and found to contain 27.5 per cent of silica in the case of No. 259 and 23.5 per cent of silica in the case of No. 260. Qualitative tests on the residues then showed the presence of iron and aluminum oxides and small amounts of calcium oxide, thus confirming the opinion that this material is clay or sand, or both.

As seen from these analyses, there is a considerable quantity of insoluble material in each deposit, which is probably in the nature of clay, sand, etc., coming from the deposits in the mains laid down prior to filtration. The silica reported was found in the soluble portion. There was also an appreciable amount of organic matter as indicated by the loss on ignition.

The combined oxides of iron and aluminum are quite low in each sample, as are also the quantities of lime and magnesia.

The frost case was of galvanized iron and the analysis of the deposit in this case, which was of a dirty white color, shows 27.32 per cent of zinc expressed as oxide. The gear case deposit was green in color and contained about 34.85 per cent of copper expressed as oxide.

Further investigations are being made along this line. The conclusions which appear reasonable regarding these incrustations at this time are:

1. That what incrustations there are may be largely due to the condition of the water during the early months of operation of the Defiance plant when the carbonation feature was often out of service for periods of several days at a time.
2. Recent experience has shown that there is still a large amount of mud in the service lines and this is often forced into the meters.
3. That a longer period of time is required for the collection of definite data.
4. There appears to be no noticeable increase in the deposits in the galvanized iron pipes and in the meters during the last six or eight months.

The design of the filter at Defiance was made by my associates, Mr. John N. Brooks, M.Am.Soc.C.E., and Mr. Allan T. Ricketts, M.Am.Soc.C.E., under my direction. Mr. Ricketts acted as Engineer in Charge during the construction. Mr. Frederick B. Barns, Assoc.M.Am.Inst.E.E., also one of my associates, was Resident Engineer. The analytical work herein presented was done by Mr. John E. Dowd, M.Am.Ch.Soc., Chemist and Bacteriologist in my office laboratory. Mr. H. T. Campion, Superindentent of the Defiance Water Works, coöperated with this office and furnished much material assistance both in the construction and breaking in of the plant.

Prof. D. D. Jackson of Columbia University gave the author some very helpful suggestions in connection with the design of the carbonating plant and application of CO_2 to the water.

In closing this paper it may be well to state that, whereas experiments have previously been made with the application of CO_2 to the effluent from water softening plants and desultory attempts have been made to use CO_2 as a final treatment in the lime softening plants as, for example, at Owensboro and Winnipeg, the Defiance plant is the first in which the CO_2 process has been developed in a practical form and has been used in actual and continuous operation. The author feels, from the results obtained at Defiance, that he is safe in saying that the CO_2 process is a decided step in advance where the lime softening process is used and that it will eliminate many troubles caused in a combined softening and filtration plant.

THE CLARION RIVER HYDRO-ELECTRIC DEVELOPMENT[1]

By Charles B. Hawley[2]

Within the last few months active construction work has been started on the first of a series of hydro-electric developments on the Clarion River. These power developments are of especial interest to the people of Pittsburgh in that the proposed dams will add to the flood protection of this district and will greatly facilitate the construction of any navigation improvements which in the future may be required on the Clarion River.

Usually the building of water powers involves more or less serious interference with previously established, or vested, interests in the right to the use of stream-flow, but the Clarion project is somewhat remarkable and fortunate in that the developments as laid out will conserve the existing vested interests.

In regard to these various interests in the right to the use of stream-flow, it may be said in general, that the chief public benefits resulting from the use of our streams are water supply, irrigation, navigation and water power development. These uses are not entirely harmonious; in fact, they are antagonistic in many respects and where a stream is put to two or more of these services, some compromise with respect to the conflicting interests is almost invariably necessary.

The use of stream flow for water supply for domestic and industrial purposes has always been considered, I believe, most important and necessary of all uses, but fortunately the amount of stream flow required for this purpose is usually insignificant in comparison with the total flow of streams which are large enough to be used for irrigation, navigation or water power. In those few cases where a large proportion of the stream flow is required for water supply, it sometimes is possible, as in the case of the Los Angeles aqueduct and water supply system, to use the water first in developing electric power before distributing it as water supply to communities.

[1] Presented before the Central States Section meeting, November 2, 1922.

[2] Consulting Engineer, Washington, D. C.

Here in the east irrigation has not as yet become a factor in determining prior rights to the use of water. However, as our country becomes older and more densely inhabited, the need for intensive farming will become greater and it is entirely probable that even our eastern streams will in a great many instances be forced to contribute water for irrigation purposes, especially in connection with those lands which are commonly termed "bottom lands" in the Central States. It is perhaps usual to think of irrigation as being required only in the dryer climates, but it is also extensively resorted to in countries which have very heavy rainfall, such as Japan, and will come into increasing use in this country as intensive farming makes it necessary.

On the other hand, the necessity for improving rivers for the purposes of navigation seems to be on the decline, except in the case of those streams which are of sufficient size and have sufficient depth of channel to make navigation easily possible. It is my opinion that the electrification of railways, which will surely continue as capital becomes available, will permit operating expenses of the railroads to be kept low enough to make railroad transportation preferable, as it is at present, for all products, where time of transit is of any consideration. Of course, there are even now many rivers where the existing use of the channel for navigation, practically blockades the stream so far as the development of water power is concerned. But as the value of electric power increases, and it is sure to do so in the future, the economical price of power development will tend toward higher levels, thus making it possible to absorb in construction charges the cost of locks which would have to be built in connection with power developments on navigable streams. In this connection we should not lose sight of the fact that these navigation facilities must be paid for by the power consumer, since development costs are reflected in power rates, with the result that the navigation interests will secure the benefits of slack water at the expense of electric power users.

The fourth important public benefit, already mentioned, as resulting from the use of our rivers, is water power, and it is not difficult to imagine the extensive series of water power developments which will be made along our streams, both large and small, within the next fifty years or so. Of course, water power development is practicable only on those streams which, having adequate stream flow, also have sufficient natural slope to permit an economical

accumulation of head by resorting to dams or conduits. Even in the case of some of these streams, the diversion and consumption of stream flow for water supply and irrigation will make hydro-electric development impossible. These instances will be rare, however, especially in view of the fact that water power projects may be laid out in so diversified a manner as to be kept within the particular limitations applying to any stream.

There are likewise other interests conflicting with water power development, but in the main all of these difficulties resolve themselves into a question of property damage, with one possible exception, and that is the occasional necessity, realized by a community, for constructing and operating dams for flood prevention purposes only. Even such dams, if properly laid out, may sometimes be operated for the joint purposes of water power and flood prevention, without undue compromise of interests.

The Clarion River, like all others of the larger streams, has its problems of interference in connection with the development of water power. These problems are chiefly in respect to the possible uses of this stream for navigation and for flood prevention as contemplated by the Pittsburgh Flood Commission. In laying out the various developments of the Clarion Hydro-Electric Project, the conflicting interests of navigation, flood prevention, and water power have been anticipated and the resulting problems effectively solved, with the result that all public interests in the stream flow of the Clarion River have been conserved. The possible future use of the stream for navigation and the present need of flood prevention in the Pittsburgh District have been provided for.

The Clarion River flows into the Allegheny River at a point between Parker's Landing and Foxburg, some 70 miles north of Pittsburgh. The drainage area of the Clarion at its mouth is nearly 1300 square miles. The hydro-electric project covers that portion of the river between its mouth and the city of Ridgway, a distance measured along the stream of approximately 90 miles, in which there is a natural fall of 475 feet.

Water power development of this stretch of river is best accomplished by the construction of three dams, the downstream dam, which we will call No. 1, to be located just a short distance above the mouth of the river; the intermediate dam, called No. 2, to be located a few miles below the Borough of Clarion; and the upstream, or Dam No. 3, located a little above the Borough of Clarion. Dam No. 1

will create a head of some 150 feet, Dam No. 2, a head of 80 feet, while Dam No. 3 will give a maximum head of 240 feet, and its reservoir will extend upstream to within a short distance of the City of Ridgway.

To develop completely the water power possibilities of any stream, equalization of stream flow throughout the year is essential. This can be realized only by the construction of dams for storage purposes. Now if a power plant is built to take water directly from such a dam, the drawdown of the reservoir incidental to the utilization of storage may so reduce the effective head on the water wheels as to reduce the power output below the normal demand on the system, although this demand could easily be met with the quantity of water available, were it not for this reduction of effective head on the turbines. When we consider that the power output of a water wheel decreases as the three halves power of the head it is apparent to what extent a reduction in head at a reservoir plant affects the total annual power output, as well as the daily power capacity. Of course, it is possible to offset this loss in power capacity of turbines by the installation of extra equipment for use at low heads only, but this involves an increased use of water at a time when the reservoir is low. If the plant is one of a series on the same river, best operating conditions will be secured by placing the requisite amount of reservoir capacity at the head waters of the river or at the dam furthest upstream, so that no loss of head due to drawdown need occur at any of the downstream plants. Another advantage of this arrangement is obvious when we consider that reservoir capacity at the plant located furthest downstream is effective for that particular plant only, whereas an equal amount of stored water at the upstream development would serve the entire series of power plants below. As mentioned before loss of head, due to drawdown of reservoir, is a very important consideration. For instance, a 50 foot drawdown in connection with No. 1 dam on the Clarion River would reduce the head on that plant by 33 per cent, and the peak load carrying capacity by 45 per cent, whereas an equal amount of drawdown at the upstream plant, No. 3, would reduce the aggregate head of the three plants, which is 470 feet, by approximately only 10 per cent, and the power by only 15 per cent. Such small reductions as these can easily be taken care of by proper proportioning of the various plant installations. Accordingly, the Clarion developments have been laid out with the intention of operating the two downstream plants with full reservoirs and practically constant

head at all times, depending entirely upon the upstream dam, No. 3, for stream flow regulation.

This program is also best suited to any future uses of the stream for navigation purposes. A fluctuation in the reservoir level would seriously interfere with the operation of locks and make navigation past a dam impossible during those times when the pond level was below the sill of the lock. Otherwise the lock chamber would have to have walls and gates of sufficient depth to extend below the minimum reservoir and lock levels by an amount equal to the depth of water required for navigation. For instance, if a lock is required around a power dam which is operated with a 50 feet drawdown, the height of the downstream lock gate would have to be 50 feet (the depth of drawdown) plus say 40 feet (the lift of the lock) plus 10 feet (the navigable depth of channel), a total of 100 feet. The construction of such gates, while not impossible, is, of course, expensive. Then, too, the fluctuation of reservoir level would interfere with the operation of dockage facilities along the reservoir, and the shipping interests would have to meet a condition even more exaggerated than that which prevails in a tidal harbor. In the case of tides normal depth of water recurs every twelve hours, but in the case of a storage reservoir a normal or maximum elevation of water could be counted upon only during the spring months after the reservoir had been filled. Accordingly, the Clarion project is best laid out with respect to navigation interests, since there will be but one fluctuating reservoir instead of several, and this reservoir will be so far upstream that there will undoubtedly never be a necessity for navigation above that point. In fact, it is difficult to imagine at this time that any portion of the Clarion River will ever be used for commercial navigation, although it is impossible to predict what changes in public necessity may occur in the future.

In a similar way, in the matter of flood prevention, the development of water power on the Clarion River will be a benefit to the Pittsburgh District. The power dams will absorb floods on the Clarion and will thus dampen the floods in the Allegheny River. Dam No. 3 will have a useful storage capacity of some thirty billion cubic feet (two hundred and twenty-five billion gallons) of water above low reservoir level. As this storage will be used to regulate the stream flow for all three of the major developments on the Clarion River, there will be comparatively few days in any series of years when the reservoir is completely full, and such days will occur

only for a brief period after the spring floods of particularly wet years. Accordingly, there would almost always be unfilled reservoir capacity available for absorbing unexpected floods on the Clarion River. Of course, with any flood prevention dam there is always danger that two floods will occur in succession, the first one filling the reservoir, making it necessary to discharge the entire peak of the second flood. But the Clarion dams will have a special factor of safety against such a contingency, in that the immense surface area of the three reservoirs will tend to absorb the peak of the second flood, even though the reservoirs are full.

As the general scheme for flood prevention in the Pittsburgh District involves the construction of dams on several of the streams which contribute their runoff to the Ohio River at Pittsburgh, it is safe to assume that a succession of two floods would not occur simultaneously or in synchronism on even two of these areas, so that in case a second flood should occur on any one of the improved streams, the other flood prevention units would have capacity to withhold temporarily the entire run-off from their respective catchment areas, thus keeping at a minimum the resultant hazard at Pittsburgh.

In the ordinary case of a dam built for flood prevention purposes only, it would be required that the reservoir be drained immediately after the occurrence of a flood or as soon thereafter as stream flow conditions below the dam permitted. Where a dam is used for the storage of water for power purposes, the water thus stored should be conserved for as long a period as possible. This essential difference in the operation of power dams and flood prevention reservoirs is of no moment in connection with the Clarion project, since, as explained before, the reservoir behind Dam No. 3 will very rarely, if ever, be at a maximum elevation for more than a few days at a time, and even when it is at a maximum elevation, the very large surface area of the three reservoirs, which have an aggregate length of nearly 90 miles, will tend to dampen effectively peak discharges during floods.

At Dayton where the Miami Conservancy Board has done most important and effective flood prevention work, the engineers have not depended entirely upon reservoir dams, since such dams are effective only with respect to relatively small catchment areas behind them. The Conservancy engineers have also resorted to channel improvements in the river at and near Dayton, including the straight-

ening, deepening and widening of the stream, and have also raised high embankment walls in order to keep floods within control.

The construction of water power dams on the Clarion River will do its part effectively to reduce floods at Pittsburgh, as will also the proposed extensive system of power dams on the Cheat River, but a suitable amount of channel improvement and embankment work, in addition to storage reservoirs on many tributary streams, may doubtless be required to afford Pittsburgh complete relief from its flood menace.

COLON-AEROGENES DIFFERENTIATION AT CINCINNATI

By Clarence Bahlman[1] and Henry Sohn[2]

Differential reactions for coli-like bacteria have received considerable attention within recent years. As a result of study by many workers, it has been demonstrated that bacteria formerly spoken of collectively as B. coli constitute a broad group of allied organisms which may be divided into at least two sub-groups, the B. coli, commonly found in the feces of man and many animals, and the B. aerogenes, rarely present in feces but predominating in the soil, in milk and on cereals. The reactions used in differentiating these bacteria, as given in the 1917 and 1920 edition of Standard Methods of Water Analysis, are shown in table 1. On account of the variability of the indole and saccharose reactions, these tests are of only subordinate value in the separation.

For several years the methyl red test has been made upon all confirmed lactose-fermenting cultures isolated at this plant, but during the year 1921 additional reactions have been employed, with the object of ascertaining whether coli-like cultures which would not conform to the reactions shown in table 1 could be isolated from our water, and to what extent such cultures would remain atypical after rejuvenation.

Unfortunately it was impossible to obtain adonite and this test had to be omitted. Chen and Rettger (1) and Winslow and Cohen (2), however, have found that adonite is attacked by aerogenes from both fecal and non-fecal sources, and hence the differential value of this alcohol seems to be discredited. Omitting adonite, then, our cultures may be divided into four sections, the well-recognized fecal B. coli; the predominantly non-fecal B. aerogenes; the B. cloacae type, of either fecal or non-fecal origin; and a fourth group in which the reactions are atypical.

Koser (3) has succeeded in differentiating the coli from the aerogenes types by the use of a medium containing no nitrogen except

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in the form of uric acid, B. aerogenes growing luxuriantly in this medium while B. coli failed to show the slightest evidence of growth. Chen and Rettger (1) also employed this medium with success, and we accordingly have included it in our studies.

Obviously the subdivision of coli-like bacteria into groups, subgroups, etc., is limited only by the number of tests employed. The fewer the number of reactions necessary to indicate the fecal or non-fecal origin of the culture, the less confusing and the more widely used will be the tests. In this work we have taken the methyl red test, the Voges-Proskauer reaction, growth or non-growth in uric acid medium and gelatin liquefaction as the only reactions necessary for the primary subdivision of the coli-like bacteria. If all of these bacteria will conform to the scheme given in Standard Methods, then cultures which are positive to methyl red should be Voges-Proskauer negative, and vice-versa. For this to be the case would be rather surprising. Since starting our work Perry and Monfort (4), in a somewhat similar study, have mentioned the difficulty of making all colon-group bacteria fit into the above system of classification, since the methyl red and Voges-Proskauer reactions of many of their cultures were not of opposite signs.

Procedure followed. Endo plates were streaked from the presumptive tube which, after forty-eight hours at 37°C., showed gas in any amount from the smallest volume of water tested. After twenty-four hours at 37°C. an agar slant was inoculated from one of the Endo colonies, whether typical or atypical, and incubated at 20°C. for forty-eight hours. This slant served as the parent culture from which the following 5 media were inoculated: lactose broth, Clark's broth, uric acid medium, peptone broth for indole test, and gelatin.

The uric acid medium was made according to Koser's formula; the other media were prepared according to Standard Methods, using Difco peptone except for the Clark's broth, in which proteose-peptone Difco was used.

The fermentation tubes were incubated forty-eight hours at 37°C., and the Clark's broth, peptone broth and uric acid medium for five days at 30°C. The gelatin cultures, after five days at 37°C., were immersed in ice-water and those which failed to congeal were recorded as liquefiers. Indole formation was determined by the Steensma-Nelson vanillin test (5). One-half of the Clark's broth culture, after incubation, was poured into a clean test tube and used for the methyl red (M.R.) test. An equal volume of 10 per cent KOH was added to the remainder of this broth, and the mixture thoroughly shaken. These tubes were then placed in the 37°C. incubator and the Voges-Proskauer (V-P) reaction recorded after eight hours.

Number of cultures studied. During 1921 a total of 1825 samples of river, settled, coagulated (sulphate of iron and lime), filtered and chlorinated waters were examined for colon-group bacteria. Positive presumptives were obtained upon 1350 of these samples. Of this number, 1156 gave gas in the secondary lactose tube, after isolation from Endo medium. When no gas was found in this tube, another fermentation tube was inoculated from the parent slant, and in this way 67 cultures formed gas on the second test, although failing to do so on the first trial. This gives a total of 1223 out of 1350 cultures, or 90.6 per cent confirmed. These 1223 cultures form the basis of our study.

Of the 67 cultures which were confirmed only on the second test, 20 were B. coli by their subsequent reactions, 40 were aerogenes and 7 (all M. R. negative) failed to conform to any of the group reactions shown in table 1. It is interesting to note at this point the high percentage of M. R. negative organisms among the cultures which failed of confirmation except by a repeat test. This peculiarity is seen also in the tabulations of Perry and Monfort (4); 29 of their 39 cultures which failed to form gas after isolation from Endo plates were M. R. negative, and of these 22 were aerogenes on the basis of the M. R. and uric acid tests.

Grouping of the cultures. The M. R., V-P., uric acid and gelatin liquefaction tests were used as the basis for grouping our cultures. Although of variable intensity, the V.-P. and the uric acid reactions were always definitely positive or negative. In the great majority of cases there was no difficulty in recognizing the M. R. colors as either positive or negative, but where there was any doubt, due to borderland or neutral tints, the reaction was recorded as $\pm$.

Gas-forming cultures which were neither coli, aerogenes or cloacae, as defined by table 1, were tentatively classed as atypical. Table 2 shows the distribution of the cultures according to our grouping, as well as a summary of the indole and gas reactions of the well-recognized groups. It will be noted that 15.3 per cent of the cultures could not be classified according to the scheme of Standard Methods.

It is recognized, of course, that the relative abundance of the various types in a water can be accurately determined only by the direct plating method. Isolation from the fermentation tube will give only an approximation of the truth, but it was impossible to burden our laboratory with so much additional work. The main object of this study was to effect a broad separation of coli-like

bacteria by a few cultural tests and then to study more intensively those cultures which proved atypical. With this procedure the presence of spore-bearing gas-formers, such as those described by Meyer (6), Ewing (7), Perry and Monfort (8), and Hinman and Levine (9), and the morphological peculiarities of the cultures, will pass unnoticed unless their cultural reactions were such as to throw them into the atypical class, since only atypical cultures were studied microscopically.

TABLE 1

Classification of coli-like cultures according to standard methods

GROUP	SOURCE	METHYL RED	VOGES-PROSKAUER	ADONITE	GELATIN	INDOLE	SACCHAROSE
B. coli ..	Fecal	+	−	−	−	Usually +	Usually −
B. aerogenes..	Fecal	−	+	+	−	Usually −	+
B. aerogenes..	Non-fecal	−	+	−	−	Usually −	+
B. cloacae.....	Fecal or non-fecal	−	+	+	+	Usually −	+

TABLE 2

Group distribution of 1223 coli-like cultures

GROUP	CULTURES		PERCENT OF CULTURES INDOLE +	PERCENT OF CULTURES SHOWING VARIOUS GAS VOLUMES		
	Number	Per cent		Under 10 per cent	10 to 40 per cent	Over 40 per cent.
B. coli	695	56.8	87.0	6.9	84.3	8.8
B. aerogenes	321	26.3	23.4	16.2	57.6	26.2
B. cloacae	20	1.6	30.0	10.0	75.0	15.0
Atypical	187	15.3				
Total	1223	100.0				

Relation between source of water and percentage of positive presumptives confirmed. As stated above, 1223 or 90.6 per cent of the 1350 presumptive positives were confirmed. It has frequently been mentioned in published reports that as water passes through the various purification steps there is a gradual decrease in the number of confirmed tests, especially in the filtered and chlorinated waters.

It seems, however, that at this plant gas-formers other than true colon-group bacteria are not nearly as numerous as at many other localities. In water from any stage of our process there has never been less than 80 per cent of the presumptives confirmed, nor has there ever been any pronounced decrease in confirmations as the water was settled, coagulated or filtered. Confirmations in the chlorinated water, however, have always averaged a few per cent less than in the unsterilized waters.

Effect of season and of source of water upon abundance of fecal and non-fecal types. The non-fecal aerogenes type is said to be relatively more numerous at times of freshets when there is considerable washing of soil into the streams, but a study of our methyl red tests for four years has failed to reveal any correlation between rainfall or stage of the river and the relative proportion of the coli and aerogenes types in the water. Our system of isolating from the fermentation tube rather than by direct plating probably is the cause of this. The aerogenes subgroup, however, is found with greater frequency during the period from May to October when the temperature of the water stimulates many biological activities; apparently this organism is better able to survive competition which inhibits the more susceptible fecal strains.

No difference between the two types was apparent as regards ability to survive the treatment in the various processes of purification; approximately the same proportion of fecal and non-fecal types being found in all the waters.

Since starting the methyl red test in 1917, a peculiar decrease in positive reactions has been noted from year to year. The percentages of confirmed cultures from all sources which were methyl red positive were as follows: 1917, 83; 1918, 77.5; 1919, 65.9; 1920, (four months), 69.5; 1921, 62.4.

Indole formation and gas-volumes of coli and aerogenes cultures. Eighty per cent of our coli cultures and 23.4 per cent of the aerogenes strains were indole positive; this is in close agreement with the findings of other workers. Chen and Rettger (1) report that all of their 173 cultures of B. coli from feces, and 75 per cent of the cultures of this organism obtained from soil were indole positive, while only 31.5 per cent of the aerogenes strains formed indole.

The percentage of gas formed in the fermentation tube is influenced by many factors and at its best is of only minor significance. It will be noted from table 2 that our aerogenes and cloacae cultures

differ from the fecal strains in that the former very frequently show gas volumes either of less than 10 or of more than 40 per cent of gas. It seems that aerogenes is very apt to develop more than 40 per cent of gas in the fermentation tube; Chen and Rettger record that only 51 of 447 aerogenes cultures fell under 40 per cent in gas volume.

Study of the atypical cultures. By grouping according to the MR, V-P. and uric acid tests there are twelve possible varieties of gelatin non-liquefiers, as shown in table 3, and the same number of corresponding liquefiers. Purely for our convenience we have designated each of these possible types by a letter, except the well-known B. coli and B. aerogenes types. The gelatin liquefying

TABLE 3

Possible varieties based upon M.R., V-P and uric acid tests

	M.R.	V-P.	URIC ACID	OUR DESIGNATION
1	+	−	−	B. coli
2	+	+	−	Type A
3	+	+	+	Type B
4	+	−	+	Type UPC
5	−	−	−	Type C
6	−	+	−	Type D
7	−	+	+	B. aerogenes
8	−	−	+	Type E
9	±	−	−	Type F
10	±	+	−	Type G
11	±	+	+	Type H
12	±	−	+	Type I

culture corresponding to aerogenes is, of course, B. cloacae. There are, then, 24 possible reactions, three of these belonging to the well-known coli, aerogenes and cloacae sections, the others belonging to unnamed organisms classed by us as atypical. In our work we grew into the habit of designating the MR positive, V-P. negative uric acid positive organism, isolated by Chen and Rettger (1) from the soil, as "uric acid positive B. coli" or as type UPC, and we shall continue to use this appellation in this discussion.

The reactions given by a culture may be the more or less fixed characteristics of one organism in pure culture, or they may represent the combined reactions of two or more different species in mixed culture. Thus a culture containing both coli and aerogenes will

react positive to each of the above three tests. Re-plating and sub-culturing therefore is necessary to prove the purity of the atypical cultures.

Procedures used on atypical cultures. A new 48 hour 20°C. agar slant was prepared and the fermentation of lactose, the M.R.,V.-P., uric acid and gelatin tests were repeated from this. If by these repeat tests the culture now fell into any of the three well-known groups (coli, aerogenes and cloacae) no further studies were made. (In studying the atypical cultures the action upon gelatin was noted after five days and also after fifteen days at 37°C.).

If the culture still remained atypical it was invigorated by four successive transplants in nutrient broth, each of these being incubated for 24 hours at 20°C., as described in the 1912 edition of Standard Methods. Gelatin plates were prepared from suitable dilutions of the last broth tube, incubated at 20°C., for 48 hours, and an agar slant inoculated from each of four of the colonies upon the plate. If the culture being studied was a gelatin liquefier, agar plates were used, so that additional sub-cultures were always available at any time during the subsequent observations.

The tests were then repeated upon the four sub-cultures. If all of these gave the same reaction as the original, the latter was assumed to have been a pure culture of an organism the cultural characteristics of which are more or less permanent, since ordinary rejuvenation caused no changes in reaction. One of the sub-cultures was then kept for additional study.

If the sub-cultures reacted differently, although one or more of them was identical with the original or was a lactose-fermenter not fitting into the Standard Methods classification, the atypical sub-cultures alone was retained for further observation. The parent culture in such a case was considered to have contained an unclassified coli-like organism in mixed culture with one or more other species.

If the original reactions were lost in all four of the sub-cultures, additional colonies were fished from the plates which in the meantime had been stored in the refrigerator. If it was impossible to duplicate the original reactions by from 7 to 10 sub-cultures from the plate, and all of these sub-cultures acted alike, then it was assumed that the original organism either was lost in the manipulations or else had undergone a change in its cultural reactions. In many instances the results upon the sub-cultures proved that there were two or more different organisms in the parent culture and that the reactions of these in the mixed culture would account for the original results.

Finally, fresh slants were prepared from all of the cultures which still remained atypical after the above procedures, and from these various carbohydrate broths (0.5 per cent) were inoculated. These were incubated for four days at 37°C. and gas formations noted after this time. A twenty-four-hour broth culture was used for motility observations; the reaction to Gram's stain was determined from a forty-eight-hour agar slant.

Grouping the atypical cultures. Table 4 shows the distribution of the 187 tentatively atypical cultures among the lettered types

mentioned above, the number of these cultures remaining after repeating the tests, and the number which still retained their original reactions after rejuvenation and replating. The percentages of these final, persistently atypical cultures which gave gas formation in the various carbohydrate broths, and the percentages showing indole formation, are also given in this table. Similar percentages for cultures of typical B. coli, B. aerogenes and B. cloacae, selected at random toward the end of the investigation and proven to be pure cultures by re-plating, have been placed at the bottom of the table for the purposes of comparison.

A detailed account of the behavior of the organisms of each type, when studied as above, will serve to throw some light upon the permanency of the reactions of cultures which cannot be included in the well-recognized groups.

ATYPICAL GELATIN NON-LIQUEFYING CULTURES

Type A (*MR+*, *VP+*, *uric acid−*): Of the 12 possible varieties of gelatin non-liquefiers, type A was the only one which we failed to encounter in this study.

Type B (*MR+*, *VP+uric acid+*): Three of these cultures were isolated in the routine work; two of these became MR negative on repetition. All of six sub-cultures from the remaining MR positive culture, moreover, gave a color with this indicator which would undoubtedly be classed as negative although four of them had a faintly orange cast. Variations in hydrogen ion concentration may be expected of all bacteria, and Chen and Rettger have shown that the composition of the media, the length of incubation and even the brand of peptone may cause discrepancies in the MR test. Our type B cultures, therefore, probably are aerogenes strains which failed to develop normal hydrogen ion concentrations under the conditions of the test.

Type UPC (*MR+*, *V-P−*, *uric acid+*): Koser (3, 10) has observed that B. aerogenes was able to develop in a medium in which uric acid furnished the only source of nitrogen while B. coli was unable to utilize the nitrogen of the purin ring and failed to grow. Chen and Rettger found, similarly, that 173 strains of B. coli isolated from feces failed to develop in the uric acid medium. They report, however, that 10 out of 20 coli strains isolated from soils grew just as luxuriantly as typical aerogenes in this medium. They point out that this lack of correlation suggests the possibility that

these strains may represent a type intermediate between coli and aerogenes.

Perry and Monfort (4) isolated 63 MR positive, uric acid positive varieties out of 392 cultures isolated from natural waters; we found a much smaller percentage, 46 out of 1223 cultures. Three of these were V-P positive and belong in our type B, the remaining 43 cultures we will speak of as "uric acid positive B. coli" or type UPC. Let us note at this point that several of these cultures were recorded as only "slightly positive" to uric acid. With all other types growth in this medium was either very pronounced or entirely lacking.

Fifteen of the 43 cultures failed to repeat. Four of these changed both their MR and VP results and became typical aerogenes; four became MR negative and thus assumed the reactions of type E, two changed from uric acid positive to uric acid negative and thus appeared to be typical B. coli. Five cultures at first appeared to repeat their original reactions although the growth in uric acid medium was not nearly as pronounced. A second repeat upon these five cultures, from the parent slant which by this time was seven days old, surprised us by failing to show any development whatsoever in the Koser medium, the cultures now appeared as typical B. coli.

The growth in uric acid of ten of the 28 cultures still remaining in type UPC, moreover, was noticeably less marked than in the original tests. It seems that for some reason these cultures were gradually losing their ability to utilize the uric acid nitrogen.

The results upon rejuvinating and replating these 28 cultures were as follows:

2 cultures showed only aerogenes in pure culture
10 cultures showed only B. coli in pure culture
6 cultures showed only type E in pure culture
1 was a mixed culture of type E and B. coli
3 (all chromogenic) were mixed cultures of B. coli and a MR negative, VP negative, uric acid positive chromogenic non-gas-former
2 cultures were mixed cultures of B. coli and a MR positive, VP negative, uric acid positive non-gas-former
4 cultures retained their original reactions

The reactions of the constituents of the six mixed cultures will account for the original results and probably there were no type UPC organisms in the first cultures. Only four of the 22 apparently pure cultures remained as type UPC, and ten of the 22 now failed to grow in uric acid medium.

Variations in the MR and VP reactions have been alluded to in the literature and have occurred frequently in our study, but, with one exception, (see type E liquefiers) all instances of a change in uric acid reaction have been confined to cultures originally MR positive, VP negative, uric acid positive. As soon as this peculiar behavior was impressed upon us, heroic efforts, involving the examination of from 10 to 15 colonies from each plate, were made to recover uric acid positive organisms in the cultures which gave this reaction when freshly isolated from the water, but which seemed to lose the characteristic after one or more platings on laboratory media.

Our failure to accomplish this seemingly indicates that the uric acid test, so permanent with all of the other varieties, is variable in the type designated by us as UPC; that the latter is an unstable variety prone to alter all three of its reactions. By a change in both the MR and VP tests it assumes the characteristics of aerogenes, by changing the MR result only it falls into type E. More frequently, however, it loses its positivity toward uric acid and then seems to be typical B. coli which temporarily had assumed the power of utilizing the uric acid nitrogen. The tendency to revert to aerogenes and the closely allied type E in some instances, and to typical B. coli in others, would seem to strengthen the suggestion put forth by Chen and Rettger, that coli strains which are positive to uric acid belong to a type intermediate between coli and aerogenes.

Type C (MR−, VP−, uric acid−): Three of these cultures, upon repeating the tests, became acid to methyl red and were then classed as fecal B. coli. There was considerable orange, however, in the color with the indicator. One of the cultures showed a faint but undoubtedly positive VP test on the second test, thus becoming type D. The 12 cultures still remaining as type C were then invigorated and replated with the following results:

1 culture became VP positive, thus changing to type D
1 culture remained negative to the three tests but no longer fermented lactose and showed sluggish liquefaction of gelatin after fifteen days at 37°C.
2 cultures showed only typical coli, with the normal distinctly acid reaction to methyl red
5 cultures contained both type C and fecal B. coli, but the acidity of the coli subcultures was not as pronounced as usual
3 cultures remained unchanged, with distinctly negative MR reactions

This type seems to be closely allied to B. coli, the MR reactions showing a tendency to become more acid and thus at least to approach the behavior of typical coli. The original negative MR reaction was still retained, however, by one-half of the cultures after the invigorating process.

Type D (MR−, VP+, uric acid−): Two of these 14 cultures, positive by presumptive test, failed to ferment lactose on the first test from the Endo plate, although a second lactose tube was positive. These two cultures and two others, on repeating all of the tests, still retained their MR, VP and uric acid reactions but again refused to give gas in lactose tubes, even when incubated anaerobically. Two of the four cultures showed spores under the microscope.

The ten remaining cultures repeated their reactions in all respects and were then invigorated and replated with the following results:

1 culture no longer fermented lactose or any of the ten other sugar and allied broths

2 cultures no longer fermented lactose even in 4 days, although they formed gas readily from dextrose, saccharose, mannite, raffinose, dextrin and salicin. Spores were not present

2 cultures contained both a type D lactose fermenter and a MR negative, VP positive, uric acid negative organism, not fermenting lactose but giving gas from dextrose, saccharose, mannite, raffinose and salicin

5 cultures apparently were pure type D strains, all formed from 20 to 40 per cent of gas in lactose broth and all of them, as well as the 2 type D cultures which had been mixed with a lactose −, dextrose+ organism, were indole negative. All seven of these cultures were gelatin negative after five days but liquefied this medium in fifteen days

The type D reactions are therefore quite permanent, none of the cultures having altered them in the course of our study, but the frequency with which the power of fermenting lactose is lost is peculiar. Type D cultures, considered here as non-liquefiers on the basis of the five-day test, were really slow liquefiers.

Type E (MR−, VP−, uric acid+): Almost one-half of our atypical cultures belong to this type. On repeating the tests, 21 of the 69 cultures developed a positive, although usually rather faint, VP reaction, while 48 repeated the original reactions. The fate of the latter cultures on rejuvenation and replating is given below:

10 became VP positive, thus appearing as aerogenes
3 remained MR negative, VP negative, uric acid positive but would no longer ferment either lactose or dextrose. These cultures were flourescent in all media
3 were mixed cultures of a MR negative, VP negative, uric acid negative lactose fermenter (type C) and a MR negative, VP negative, uric acid positive chomogenic non-gas former
2 were mixed cultures of B. coli and a MR negative, VP negative, uric acid positive chromogenic non-gas former; a rather unexpected instance where a MR negative organism obscured the MR positive reaction of the coli
4 were mixed cultures of type E and a MR negative, VP negative, uric acid negative chromogenic non-gas former, liquefying gelatin after fifteen days but not after five days
26 still persisted as a type E, apparently in the pure culture. Ten of these were rejuvenated and replated a second time and the tests repeated. All of the 10 still gave the type E reactions

It was noted in the routine work that many of the type E cultures were decidedly fluorescent in all the media, but in all cases the chromogenesis was subsequently shown to be caused by a contaminating non-gas former.

In being permanently MR negative and uric acid positive and because of their so frequently becoming VP positive it would seem that type E is to be regarded as a variant of aerogenes.

Type F, G, H, I: On repeating the tests upon the 16 cultures which yielded neutral tints with methyl red the reaction in 11 instances became definitely positive or negative, while 5 cultures (all type I) still gave indeterminate colorations. On replating, however, all of the 16 cultures gave clear-cut methyl red reactions and in no instances could mixed cultures be demonstrated.

The type F cultures were the only ones which became MR positive the cultures then appearing to be typical B. coli.

The type G culture, by becoming MR positive then had the characteristics type D and, like the latter cultures, gelatin liquefaction, negative in five days, was positive after fifteen days incubation.

The 3 type H cultures became MR negative and lost their VP reaction. The subcultures, moreover, showed only a slight growth in the uric acid medium; our type H cultures had therefore changed to type E. Additional subcultures were examined but in no instance were we able to recover VP positive bacteria.

The 5 type I cultures also fell into type E after replating.

ATYPICAL GELATIN-LIQUEFYING LACTOSE FERMENTERS

Type C gelatin liquefiers: One of these cultures gave deep red colorations in all media. Replating showed the culture to contain a type C non-liquefying gas former and chromogenic type C bacillus which liquefied gelatin and would not frement lactose.

The other two cultures, however, were shown to be pure by the replating procedures, all subcultures yielding type C reactions, fermenting lactose and liquefying gelatin.

Type D liquefiers: All six of these cultures repeated their reaction. On replating the following results were obtained, no mixed cultures being found: 2 cultures no longer reacted to the VP test nor liquefied gelatin even after fifteen days, then appearing as type C cultures. One culture retained its MR, VP and uric acid reactions but no longer fermented any of the sugars, etc., shown in table 4. 2 cultures, while retaining their type D reactions, now refused to ferment lactose although forming gas from dextrose, saccharose, mannite and dextrin. Spores were found in one of these cultures. 1 culture remained a type D gelatin liquefier lactose frementer after replating.

There is really no difference between our type D and the type D gelatin liquefiers, since the former was shown to be a slow liquefier. It is peculiar that so many of these cultures (10 out of 20) should have lost their lactose-forming properties.

Type E gelatin liquefiers: Gas formation was lost on repeating the tests upon 4 of these cultures; 1 culture developed a faint VP reaction and then appeared to be cloacae, while 4 cultures retained their original characteristics.

Subcultures from one of the latter 4 cultures no longer liquefied gelatin, uric acid positivity disappeared and the MR reaction changed to positive, in other words, the culture now appeared as typical B. coli. Two of the 4 cultures on rejuvenation gave the VP test, thus acting like cloacae, while the remaining culture was the only one from which a type E liquefying gas former was recovered, although some of its subcultures were cloacae with fairly intense VP reactions.

The type E gelatin liquefying reactions, therefore, seem to be largely due to a variant of B. cloacae which finds difficulty in yielding the VP test.

Type B. coli liquefier (MR+, VP−, uric acid−, gelatin+): Seven of these 8 cultures were chromogenic in all media. On replating,

TABLE 4

Distribution and carbohydrate reactions of atypical cultures

TYPE	REACTION				NUMBER OF ORIGINAL CULTURES	NUMBER CULTURES REMAINING AFTER		PER CENT OF CULTURES REMAINING AFTER REJUVENATION WHICH FORMED GAS FROM										PER CENT INDOL +
	M. R.	V-P.	Uric acid	Gelatin (5 days)		Repeat test	Rejuvenated	Dextrose	Lactose	Dulcite	Saccharose	Mannite	Raffinose	Inulin	Starch	Glycerine	Dextrine	Salicin	
A	+	+	−	−	0	0	0												
B	+	+	+	−	3	1	0												
UPC	+	−	+	−	43	28	4	100	100	0	100	100	100	0	0	0	25	100	75
C	−	−	−	−	16	12	8	100	100	17	100	100	100	0	0	100	25	0	100
D	−	+	−	−*	14	10	7	100	100	0	100	100	100	0	0	0	100	100	0
E	−	−	+	−	69	48	30	100	100	23	97	100	100	23	75	92	98	98	70
F	±	−	−	−	7	0	0												
G	±	+	−	−*	1	0	0												
H	±	+	+	−	3	0	0												
I	±	−	+	−	5	5	0												
C, liquefr	−	−	−	+	3	3	2	100	100	50	0	100	0	0	0	0	100	0	100
D, liquefr	−	+	−	+	6	6	1	100	100	0	100	100	100	0	0	0	100	100	0
E, liquefr	−	−	+	+	9	4	1	100	100	0	100	100	100	0	0	0	0	100	0
B. coli liq	+	−	−	+	8	8	0												
Total					187	125	53												
B. coli	+	−	−	−			30	100	100	27	47	100	53	0	0	87	0	33	
B. aerogenes	−	+	+	−			30	100	100	50	100	100	100	0	20	100	10	100	
B. cloacae	−	+	+	+			30	100	100	47	100	100	100	0	13	27	60	100	

* Gelatin + in 15 days.

5 of the chromogenic cultures were shown to be mixed cultures containing typical B. coli and a chromogenic gelatin positive lactose non-fermenter acting negative to the MR, VP and uric acid tests. All subcultures from the remaining two chromogenic forms failed to ferment lactose, the original gas-producer probably having been lost or overgrown in the manipulations. (Throughout the entire study, whenever a chromogenic lactose-fermenting culture was obtained, the chromogenesis in all cases was shown to be due to the presence of bacteria which formed no gas from lactose.)

The non-chromogenic culture became MR negative on replating, thus appearing to be a type C liquefier in pure culture.

Carbohydrate reactions. In order to compare the 53 atypical cultures with typical strains in respect to gas formation from various carbohydrates, 30 pure cultures each of coli, aerogenes and cloacae were obtained by rejuvenation and replating. Several aerogenes cultures, gelatin negative in 5 days, proved to be liquefiers after the fifteen day incubation and then were classed as cloacae. Cloacae cultures therefore were really more numerous, and aergoenes less numerous, than reported earlier in this paper on the basis of a 5 day gelatin test.

To express the results as "percentages of cultures which formed gas," as we have done in table 4, gives us a crude means of comparing the data, but too much reliance should not be placed upon the results because the number of cultures of each type in most instances is too small to permit of definite conclusions as to the gas reactions.

The 8 type D cultures were the only strains which could not be subdivided by the carbohydrate reactions, but the members of all of the other types could be further differentiated by their variable reactions with dulcite, saccharose, raffinose, inulin, starch, glycerin, dextrin and salicin. Table 4 shows that all of the 53 atypical and 90 typical cultures formed gas from dextrose, lactose and mannite, while saccharose, raffinose and salicin were also fermented by the majority of strains.

It is known that practically all gelatin non-liquefiers of the colon group will ferment glycerin, while the gelatin positive cultures are mostly glycerin negative. With the exception of type UPC, all of our atypical cultures show a good correlation of these tests, but 13 per cent of the non-liquefying coli strains were also glycerin negative and 27 per cent of the cloacae strains were glycerin positive.

The type E cultures are unique in that they were the only cultures fermenting inulin and because as high as 75 per cent of them fermented starch. The close relationship of these organisms to B. aerogenes, indicated by their behavior following rejuvenation, is again shown by their ability to ferment starch.

MICROSCOPIC CHARACTERISTICS

Microscopic examination. A microscopic examination was made upon the 53 atypical and 90 typical cultures used in studying the fermentation reactions. Except in a few instances any difference between the types, as revealed by this examination, were not of sufficient magnitude to be worthy of much note.

All of the cultures were Gram-negative and free from spores. In morphology and in motility as revealed in hanging drops there often was a slight difference even among the cultures belonging to the same group. Most of the coli cultures were short rods, rather sluggishly motile, although some were almost coccoid and a few were non-motile. The cloacae cultures generally were more actively motile than the coli. Twenty-two of the aerogenes cultures were either non-motile or else endowed with a rather doubtful sluggish movement, the others were sluggishly motile. A faint capsule was demonstrated on one of these cultures which showed ropiness on agar.

Among the atypicals there was the usual slight variations in size and shape, although all were distinctly bacilli. The four UPC cultures and the 8 type C cultures all were exceedingly motile, giving the appearance of vigorous typhoid bacilli in hanging drop. The other atypical groups showed different degrees of motility among the members of each group, but none of them approached the activity of the UPC and type C cultures.

SUMMARY

1. Confirmed colon group cultures numbering 1223 were grouped according to their methyl red, Voges-Proskauer, uric acid and gelatin reactions. Of these cultures 56.8 per cent were B. coli, 26.3 per cent were B. aerogenes, 1.6 per cent were B. cloacae and 15.3 per cent (187 cultures) were classed as atypical.

2. Correlation of rainfall and high river stages with the relative abundance of coli and aerogenes was not apparent, nor did the

degree to which the water was purified have any bearing upon the incidence of these two sub-groups. For several years, however, the aerogenes strains were found with greater frequency from May to October, and occasionally were the preponderant types during warm weather.

3. On the basis of the methyl red, Voges-Proskauer, uric acid and gelatin reactions there are 24 possible types of lactose fermenters; three of these are the well-known coli; aerogenes and cloacae types and the remaining 21 are unclassified.

4. Fourteen of these 21 possibilities were represented in the 187 atypical cultures encountered in our routine work.

5. On repeating the tests upon these 187 cultures, 45 reverted to typical coli, aerogenes or cloacae; 9 changed one or two of their reactions and thereby entered into one of the other atypical groups; 8 no longer fermented lactose, and 125, representing 10 of the 21 possible types, retained their original reactions.

6. The invigoration and replating of these 125 cultures showed that the reactions of 17 were due to mixed cultures; 12 no longer fermented lactose, 28 assumed typical reactions, 15 changed over into another atypical class, and 53, (representing 7 of the 21 types and 4.3 per cent of the total number of cultures) retained their original reactions, without any indication of the presence of contaminating forms.

7. During this study there were 33 instances of a change in methyl red reactions, 38 of a change in Voges-Proskauer, 9 where both of these tests changed, and 19 instances where the uric acid reaction altered. With one exception, all of the changes in the latter reaction were confined to one of the atypical varieties, which appeared to be intermediate between coli and aerogenes and to lose its positivity toward uric acid after growing for some time on laboratory media.

8. The fate of the atypical cultures on invigoration has been outlined, from which it appears that, although many of the non-correlated reactions were due to mixed cultures and many of the apparently pure strains showed a close relationship to typical forms, still a large proportion of the atypicals (28.3 per cent) consistently retained their original characters.

9. Most of the atypical groups could be further subdivided by their carbohydrate fermentations. The MR negative, VP negative, uric acid positive non-liquefying strains differed markedly from the other typical and atypical groups in the frequency with which they fermented inulin and starch.

10. All of the persistently atypical cultures were Gram negative, non-spore-forming rods. All of the type UPC and type C cultures showed very active motility; the other types were either non-motile or only sluggishly motile, and slight differences were noted between members of the same group.

CONCLUSIONS

Purification of cultures which do not fit into the well-defined subdivisions of the colon group of bacteria will materially reduce the number of non-correlating reactions, but many of the atypical cultures are quite permanent. In this work 53 cultures (4.3 per cent of the number studied), representing seven different non-conforming types, survived the invigoration and replating processes and remained atypical in apparently pure culture.

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THE CONSTRUCTION OF LOCH RAVEN DAM[1]

By Wm. A. Megraw[2]

Baltimore is engaged in making what is known as the Gunpowder improvement to its water supply. The plans include a dam at Loch Raven on the Gunpowder river to impound 23 billion gallons of water, and a balancing reservoir to limit the pressure on a 7 mile tunnel conducting water to the city, together with the necessary relocation of roads and bridges, the purchase and removal of the villages of Warren and Phoenix, the relocation of 1.5 miles of Pennsylvania Railroad tracks near Phoenix, the purchase of about 4000 acres of land from 54 different owners and clearing the ground to be flooded of buildings, trees and vegetable matter.

The principal feature is the Loch Raven Dam, which is nearing completion. Plans were first prepared in 1913 and the work completed during year to elevation 188 feet above mean tide, the base being made broad enough to support the additional section necessary for raising the dam later to elevation 270. The plans, under which the present contract is proceeding, provide to raise the dam from elevation 188 to elevation 240. The dam is a solid concrete structure, 640 feet long over all. The spillway is 288 feet long and rises about 103 feet above bed rock. (See figures 1 and 2.)

In designing the cross section, upward pressure was assumed on all horizontal joints, equal to the full hydrostatic pressure at the upstream face, decreasing to zero at the downstream face. Porous drains in the horizontal joints, which will be described later, are provided to relieve upward pressure. Two 48 inch pipes passing through the old foundations control the ordinary flow of the river and enabled all concrete to be deposited on dry surfaces. One inch bent steel rods 5 feet apart horizontally and vertically, imbedded three inches back of the down stream face, can be straightened to assist in binding the new concrete to the old, in case the dam is ever raised to a higher elevation.

[1] Presented before the Philadelphia Convention, May 16, 1922.

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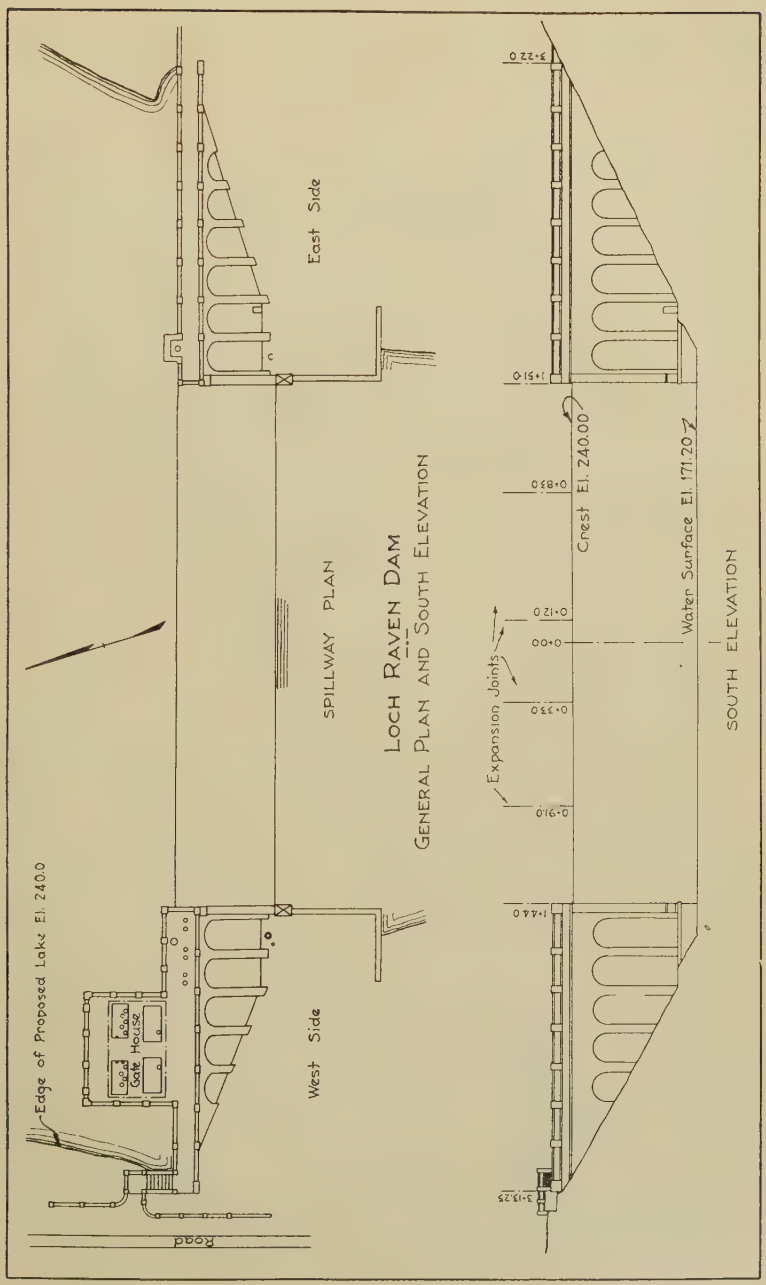
Loch Raven Dam
General Plan and South Elevation
East Side
Spillway Plan
West Side
Edge of Proposed Lake El. 240.0
Gate House
Road
Expansion Joints
Crest El. 240.00
Water Surface El. 171.20
South Elevation

FIG. 1

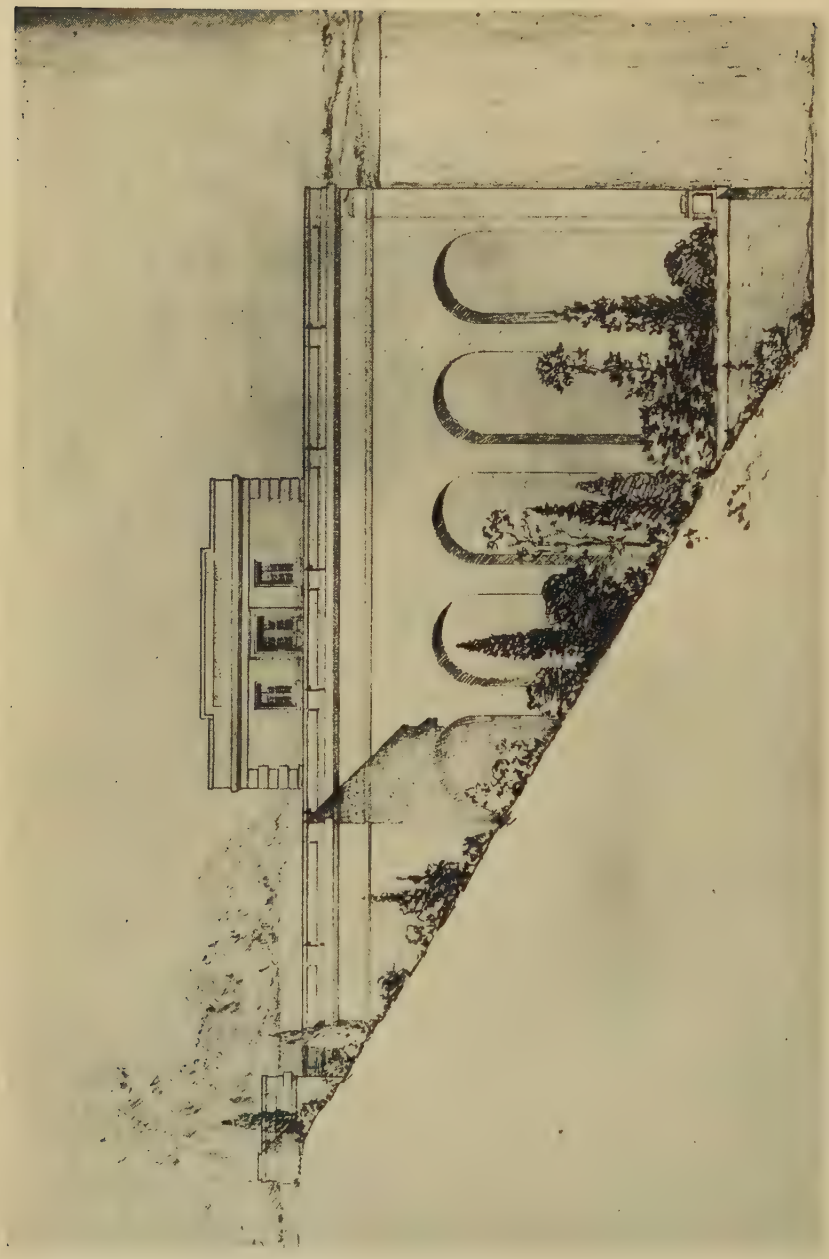

FIG. 2

The gate chamber is divided into two separate compartments and each is designed to supply the city separately. Fifteen sluice gates, $3\frac{1}{2}$ by 6 feet, arranged at different heights, control the entrance of water.

The dam is located between steep hillsides and the available working space is small. (See figure 3.) Stone was furnished from a city quarry located on the west side of the river 3000 feet down stream from the dam. An improved highway extends from a point on the hillside opposite and above the dam down to and past the quarry to Loch Raven Station on the Maryland and Pennsylvania Railroad about 2200 feet farther down. The railroad at Loch Raven Station is approximately at right angles to the river and follows along a steep hillside about 50 feet above the highway, which turns and parallels the railroad in both directions. A siding about 1600 feet west of the railwoad station provides a means of handling materials from the railroad by gravity to the highway below. An old city-owned siding 1.6 miles long is located on the east side of the river and extends from the dam southerly to a point where the railroad, 1.2 miles east of Loch Raven Station, meets it at grade. This arrangement of highways, railroads and sidings, offered several means of handling the work of construction.

The contract was awarded to the Whiting-Turner Construction Company of Baltimore on April 6, 1921, and about July 1, the first concrete was deposited. The bulk of the work was completed by January 1, 1922.

The specifications permitted the use of cyclopean concrete, but the contractor installed a chute system for distribution, which precluded the depositing of large stones, except in the east shore section, where a derrick, used for excavating the east abutment, swung a portion of the larger stones into the dam. The chute system was designed by the Lakewood Engineering Company. (See figure 4.)

On the west side of the river, the topographical conditions are ideal for a gravity plant. The contractor, availing himself of this advantage, located his crusher, storage bins and mixing and distributing plant up and down the west hillside just south of the site for the dam, although the city siding on the opposite side of the river connected the dam directly with the main line of a railroad.

Cement was the only material hauled by railroad. On the hillside below the siding at Loch Raven Station, a cement house was built with the capacity of 5000 barrels. The cement was here received in

LOCH RAVEN DAM
LOCATION PLAN
LOCH RAVEN DAM TO BE RAISED
RAVEN
LOCH
Reservoir
Old Stone Dam
Existing Spur Track Summerfield Sta. to Dam
GUNPOWDER
FALLS
Pennsylvania
Railroad
Maryland
Loch Raven Sta
10'-0" Conduit
Gate Keeper's House
21'-0" Tunnel
250
200
150
300

FIG 3

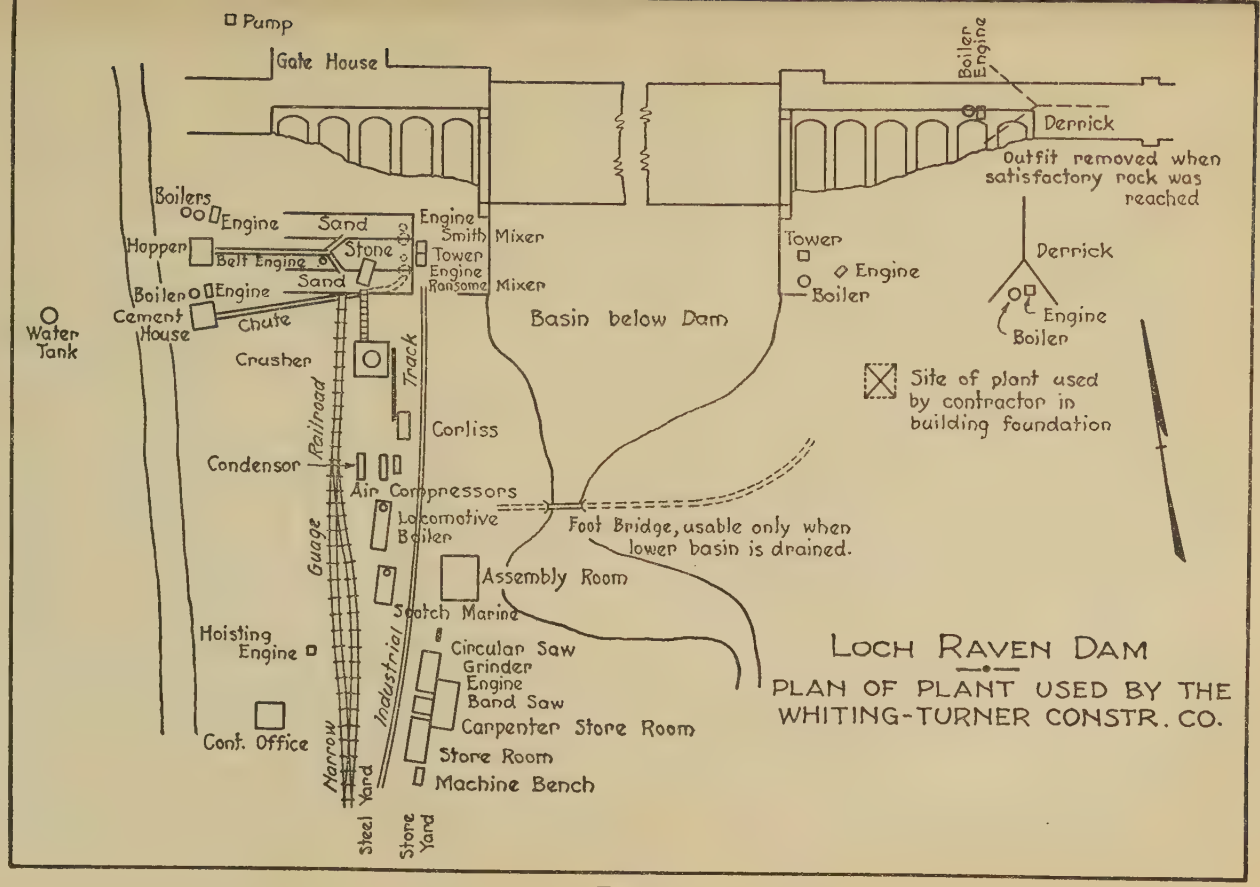
Pump
Gate House
Boiler Engine
Derrick
Outfit removed when satisfactory rock was reached
Boilers
Engine
Sand
Engine Smith Mixer
Hopper
Belt Engine
Stone
Tower Engine Ransome Mixer
Boiler
Engine
Sand
Cement House
Chute
Water Tank
Crusher
Basin below Dam
Tower
Engine
Boiler
Derrick
Engine
Boiler
Site of plant used by contractor in building foundation
Railroad
Track
Corliss
Condensor
Air Compressors
Locomotive Boiler
Foot Bridge, usable only when lower basin is drained.
Guage
Assembly Room
Scotch Marine
Hoisting Engine
Circular Saw
Grinder
Engine
Band Saw
Industrial
Carpenter Store Room
Cont. Office
Store Room
Narrow
Machine Bench
Steel Yard
Store Yard
LOCH RAVEN DAM
PLAN OF PLANT USED BY THE WHITING-TURNER CONSTR. CO.

FIG. 4

bags and handled by a belt conveyor operated by a gasoline engine which also operated a bag shaker consisting of a wire cage rotating about seven minutes for each charge. By means of a chute the bags of cement were passed to trucks. The trucks transported the cement to a 200 barrel capacity shed located on the hillside above the plant, whence it was conveyed directly to the mixer platform by chutes.

The neighborhood sand is generally not suitable for concrete, but the contractor was able to locate an excellent sand pit about 2 miles from the dam. The cost of sand at the pit was 24 cents per cubic yard and the cost of trucking 44 cents per cubic yard, making a total of 68 cents for the sand delivered. The quotation for river sand shipped from Baltimore was 70 cents per ton plus $1.14 for freight, which is the equivalent of $1.45 per cubic yard. The contractor was thus saved 75 cents per yard and the delays consequent to rail shipment. The sand was excavated by a three-quarter yard revolving steam shovel and transported by motor trucks to a point above the plant and dumped directly into a hopper at the elevation of the highway, from which a belt conveyor carried it to two large storage bins, one of which is located on each side of the stone bin. The total capacity of the two bins is 500 cubic yards.

The sand contained a maximum of 10 per cent of clay which was twice the amount authorized by the specifications. It was accepted only after thorough tests were made. One to three mortar briquettes showed an average of 250 pounds per square inch, which is 50 pounds above the standard requirement. At different times, as the work progressed, 4 inch cubes were made from concrete as it passed from the chutes into the dam. The compressive strength of these cubes at the end of 28 days, averaged 1800 pounds for 1-3-6 concrete and 2200 pounds for 1-2-4 concrete. The sand was well graded from small to large and contained a considerable percentage of gravel for which reduction was made in the stone. The clay seemed to lubricate the concrete, causing it to be more easily mixed, chuted and worked. The concrete produced a smaller amount of laitance than is usual and honeycombing is almost entirely absent from the dam.

The stone was taken from the city quarry with no expense other than that of actual quarrying. For each blast, two large well drillers were used to put down about 10 holes 12 feet apart and 85 feet deep, located parallel to and 20 feet back of the quarry face. Three large blasts, each requiring about 4200 pounds of dynamite, made at different times as the work progressed, were required to

throw down the necessary 45,000 yards of rock. After each shot, considerable secondary drilling was done by various kinds of drills, and tripod and jackhammer, besides a large amount of mud capping, in order to reduce the stone to stream shovel size. The air used by the drills was piped from the power plant located below the dam. A $\frac{3}{4}$ yard Erie shovel used at the beginning of the job soon proved insufficient and was replaced by a 90 ton Marion shovel for loading the stone into dump cars.

The cars were hauled a half mile to the dam over a 36 inch gauge track by an 18 ton dinkey, 4 cars constituting a train. As the track approached the dam, it was elevated on a trestle at 5.8 per cent grade and dumped directly into a 1500 ton gyratory crusher. A hoisting engine was used to spot the cars up the incline to the front of the crusher, which enabled the locomotive to return for another train while the first trainload was dumped and crushed. From the crusher the broken stone was raised to an overhead bin by means of a belt conveyor. The stone bin has a capacity of 1000 cubic yards and is located between the two sand bins.

Water for the concrete is taken from the river above the dam and measured by two barrels pivoted on their centers and so placed that each will empty into a mixer by hand. Each barrel has a $2\frac{1}{2}$ inch quick opening valve and a mark on the inside to indicate the quantity of water desired.

The sand and stone bins each discharge through a separate chute to a hopper located over a concrete mixer, the hopper being calibrated to measure the quantity of sand and stone required for one batch of concrete and designed to dump all material simultaneously into the mixers. Two one-yard mixers have been used, a Smith tilting mixer and a Ransome non-tilting mixer. For work of this character it developed that the Smith tilting mixer gave better results than the Ransome non-tilting mixer.

The concrete is elevated from the mixers by buckets operating inside of a double wooden tower 204 feet high and distributed by chutes to the desired points. The concrete buckets are raised by engines, one for each bucket, located at the elevation of the highway about 75 feet above the bottom of the lower pit (fig. 5).

The dam is built in 60 foot lengths, separated by transverse expansion joints extending continuously through the cross section. $\frac{5}{16}$ by 12 inch vertical steel plates, placed 18 inches back of the up-stream face, are intended to seal the expansion joints. The up-stream

face of the dam is composed of 1-2-4 concrete placed in 8 foot lifts extending alternately 6 and 7 feet back from the face. The remainder of the section is composed of 1-3-6 concrete. The following concreting procedure generally was followed:

First, a lift of 1-2-4 concrete, 60 feet long between expansion joints was deposited. After twelve hours, the forms were removed and 1-3-6 concrete was then deposited in one operation from the back of the 1-2-4 concrete to the down-stream face and for a full length between expansion joints. The 1-3-6 concrete was generally brought 1 foot higher then the 1-2-4 concrete. The two grades of concrete thus break joints both horizontally and vertically and the only vertical joints, except the expansion joints, are those between the two grades of concrete.

A 6 by 12 inch horizontal bonding groove, 2 feet back of the front face and a 14 by 14 inch porous block drain 2 feet further back from the face were placed in the 1-2-4 concrete at the completion of each lift. The bonding groove and groove for the tile drain were cut out by hand as soon as the concrete had sufficiently hardened. The ends of the tile drain are covered with burlap dipped in tar, and the space between the tile and groove filled with dry sand. At each expansion joint, the porous drain enters a 3 by 3 feet well, extending vertically upward and downward to galleries respectively above and below the highest and lowest horizontal joints, by means of which inspection can be made of the seepage through the dam. The lower gallery is drained into the tail water on the downstream side. Vertical bonding grooves 2 feet wide by 7 inches deep and 10 feet apart, bond the masonry across the expansion joints.

The 1-2-4 concrete shown on the plans for the downstream face was omitted and 1-3-6, deposited as described above, was substituted. The placing of forms on the downstream face presented a problem. There was no way of supporting them from the interior without leaving considerable timber in the concrete, and supporting them from the outside would have been expensive. The problem was solved by wiring the forms to dowels inserted in the existing concrete. A few props held the forms in place ready for pouring. As the concrete was deposited, the pressure soon became sufficient to keep the forms from collapsing, and the props were then removed. It was necessary to drill holes in the old foundation concrete for the dowels, but above that elevation, at the end of each day's pour, as soon as the concrete had set sufficiently, pieces of scrap pipe were put in place to serve as dowels.

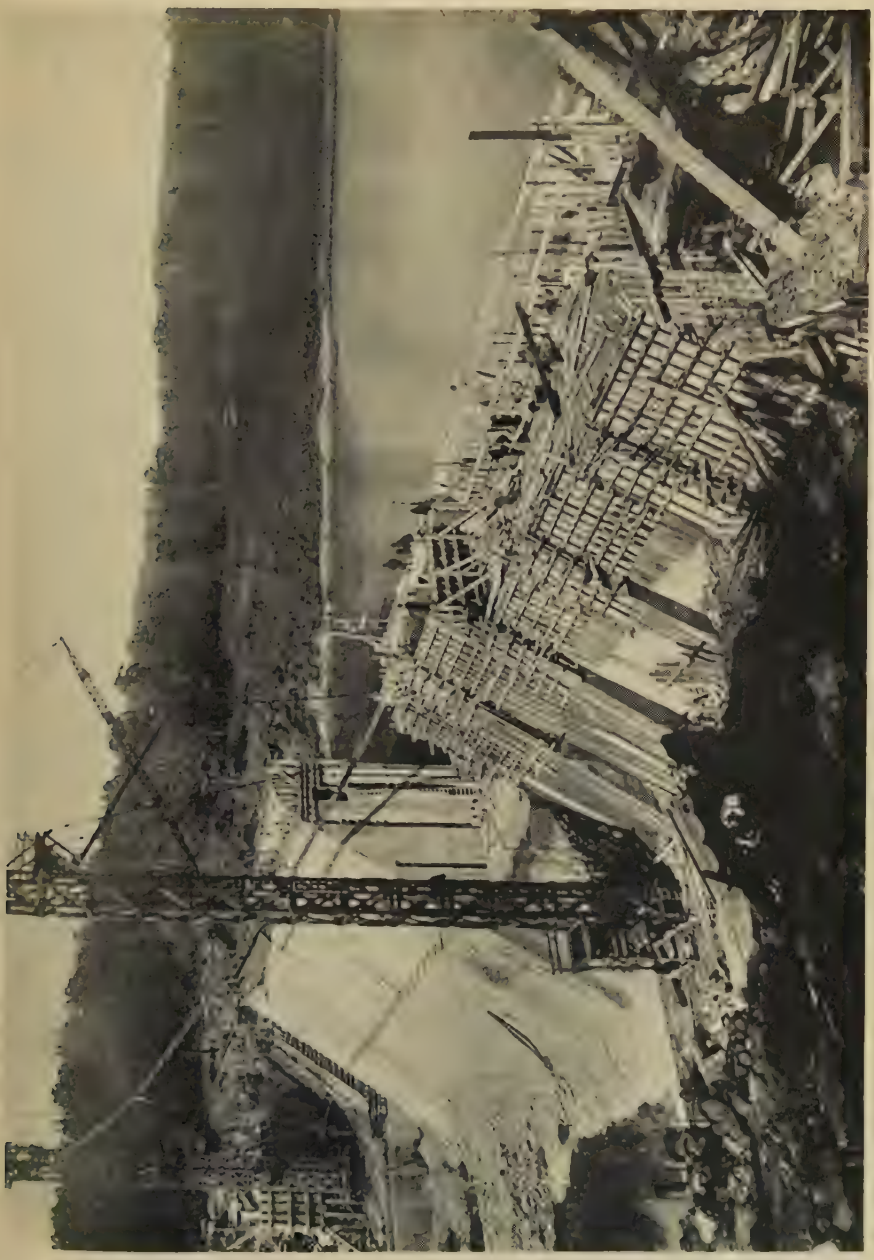

FIG. 6

In the gate chamber one 24 by 24 inch and eleven 6 by 3.5 feet gates were placed. The specifications provided that all gates be securely blocked and fastened in position before concreting. The gates will be operated by stems varying in length from 50 to 75 feet and were required to be set exactly plumb; but as each gate weighs 4700 pounds, it was practically impossible, with the means available, to sustain them in place while concreting around them. In construction therefore, the bolts for the gate frames were set as the concrete was deposited and the gates and gate frames were set after concreting of the gate chamber was completed.

The rock stratification on the east hillside is so much inclined from the horizontal that it was impossible to expose a large face without causing a rock slide. It was possible, however, by stepping the foundation to keep a rugged wall of rock against which to place concrete. About 2000 yards of solid rock were estimated, but owing to the sliding tendency, over 5000 yards were excavated. Excavation for the east abutment was started before completion of the construction plant, yet, due to the difficulties encountered, this portion of the dam was the last completed.

In order to convey concrete from the mixers on the west side of the river to the easterly part of the east abutment, the concrete was rehandled at the east tower. An elevator bucket within the tower was filled from the line chute, then elevated, and the contents emptied into a second chute higher on the tower. The east tower is 168 feet high and the west tower 204 feet high. The towers are 340 feet apart and connected by a $1\frac{3}{4}$ inch cable which carries the concreting chute.

The capacity of the plant is about 600 cubic yards of concrete per 10 hour day, although at times 700 cubic yards have been placed in the same time. The average per working day was 300 cubic yards. A considerable portion of the contractor's plant had been used before, but the loss due to breakdowns was not excessive. The records of the Resident Engineer show a loss of 483 working hours. Of this time 48 per cent was due to breakdowns and other troubles with the mixers, 22 per cent to changing and clogging of chutes, 14 per cent to accidents in the towers and 15 per cent to lack of forming space and other causes. On the whole the work progressed with rapidity, which was due in part to the hearty coöperation between the contractor and the engineers.

About 45,000 yards of concrete are required under the present contract, and the cost of all items will amount to about $525,000. The principal unit prices are as follows:

Loose rock excavation	$4.69 per cubic yard
Solid rock excavation	6.67 per cubic yard
Concrete for balustrades	20.60 per cubic yard
1-2-4 mass concrete	11.85 per cubic yard
1-3-6 mass concrete	10.34 per cubic yard
Steel reinforcement	0.04¾ per pound

50,800 cubic yards of 1-2.5-5 and 1-2-4 concrete were placed under a previous contract, the cost of all work under which amounted to $527,000. The total cost of the dam from bottom to top is therefore, $1,052,000.

The writer is indebted to Mr. C. K. Allen, Resident Engineer, for a portion of the information contained in this article.

THE USE OF CHLORINE TO ASSIST COAGULATION[1]

By Robert Spurr Weston[2]

Because of the limited time allowable, the omission of historical references is necessary but this paper cannot be given without reference to Mr. Arthur L. Gammage's[3] paper in the *Engineering News-Record* of September 7, 1922, entitled "The Prechlorination-Alum Treatment of Soft, Colored Waters." This article is worth more than a casual reading as it contains the results of numerous laboratory experiments and of several years of experience with water purification plants supervised by the writer's firm. This paper is written, therefore, with the hope that the results given by Mr. Gammage will receive more attention by plant operators.

Experience at Exeter, N. H.

The Exeter purification plant was built in 1906 to treat the water stored in an unstripped impounding reservoir which flooded several peat bogs and banks and bottom of boulder clay. The water is of the peaty type,—soft, colored, sometimes turbid, and always difficult to treat even with good mixing and an unusually long period of coagulation. The difficulties were increased following the raising of the reservoir dam in 1909 and again in 1916, thereby flooding additional unstripped areas. The average analytical results during 1913 when the water was treated with an average of 32.6 parts of sulfate of alumina per million, nearly 2 g.p.g., are given in table 1.

Owing to the difficulties in operation, namely the choice between the evils of under-coagulation with inadequate purification or over-coagulation with corrosion, the accumulations of slimy coatings and mud balls in the filter sand, the high percentage of wash water and the at times unpleasant vegetable taste of the filtered water, various expedients were tried.

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Weston and Sampson, Consulting Engineers, 14 Beacon St., Boston.

[3] Chief Chemist, Weston and Sampson, 14 Beacon St., Boston, Mass.

The plant was designed with wide allowances and operated at a low rate. In 1913, the wash water supply was increased and an air-washing system installed. Still the difficulties prevailed, and in November of that year, they were unusually great. By treatment with alum alone, coagulation was poor, mud balls were troublesome and the color was reduced insufficiently. It was decided, therefore, to apply chlorine in the form of bleaching powder, mixed directly with the alum, and fed through the same apparatus. Ac-

TABLE 1

Average results of analyses of samples of reservoir water and filter effluent at Exeter, N. H., 1913

DETERMINATION	PARTS PER MILLION	
	Reservoir water	Filtered water
Cold odor	1.0 veg.	0
Hot odor	3.0 veg.	2.0 veg.
Turbidity	16.0	3.0
Color	80.0	27.0
Oxygen consumed	8.23	3.75
Free ammonia	0.050	0.083
Albuminoid ammonia	0.306	0.159
Nitrites	0.000	0.001
Nitrates	0.13	0.12
Chlorine	4.90	5.12
Hardness by soap	27.5	33.6
Alkalinity	16.9	12.4
Residue on evaporation, total	79.0	80.0
Iron	0.84	0.30
Bacteria at 20°C	408.0	39.0
Bacteria at 37.5°C	193.0	32.0
B. coli, presumptive	4 out of 6 positive	0
B. coli in 10 cc	0	0

cordingly, in December 1913, bleaching powder was sent to Exeter, and on January 12, 1914, Mr. Gammage was sent there to determine the proper dosage.

At first, the bleach, mixed with sulfate of alumina solution, was applied in amounts equivalent to 1 part of available chlorine per million. Later the dose was reduced to less than 0.6 p.p.m. It was found that the addition of 0.7 part of chlorine per million effected the following change in the character of the effluent:

Subsequently chlorine gas was substituted for bleach, and the average dose decreased to 0.6 p.p.m. or less. This has been the only modification in eight years. However, the better purification decreased the amount of organic matter in the effluent and consequently the amount of matter accumulating on the insides of the services. To reduce the increasing corrosive effect, soda was added whenever the alkalinity was low, thereby decreasing the concentration of hydrogen ions. Soda was first added to the reservoir water, but with the realization of the fact that the best condition for the coagulation of color is one of low pH value, and that for the prevention of corrosion one of high pH value, the treatments were

TABLE 2

Significant results of analyses of filter effluent with and without the use of chlorine

	PARTS PER MILLION	
	December 30, 1913	February 3, 1914
Chlorine added	0	0.7
Turbidity	2.0	1.0
Color	15.0	1.0
Oxygen consumed	3.68	1.88
Nitrogen as albuminoid ammonia	0.170	0.034
Nitrogen as nitrites	0.000	0.000
Iron	0.22	0.10
Increase in chlorine	0.00	0.28
Bacteria per cc. at 20°C	45.0	6.0
Bacteria per cc. at 37.5°C	6.0	1.0

separated. Alum and chlorine are now added to the raw water, and soda when it is necessary, is added to the effluent.

Subsequently, Mr. Gammage made the experiments at Belfast, the results of which have been published, and the process has been applied by our firm at the Acadia Mills and elsewhere. It has also been used by Mr. Caird at Rensselaer. Recently Mr. Howard has published the results of similar work at Toronto.

GENERAL OBSERVATIONS

In 1913, the average engineer concerned with the problem of purifying a colored water with a low alkalinity would have used large doses of alum with enough alkali to insure an alkalinity of

8 to 10 p.p.m. in the filtered water. In other words, he would increase the color absorption by increasing the bulk of the precipitate. In the writer's mind at least, there was little thought of the bearing of ionic concentrations upon the problem.

It was understood, however, that color was colloidal and of two kinds, charged negatively and positively, respectively. Obviously, the positively charged color particles would not be coagulated readily by the positively charged hydrate particles and treatment with alum would remove the negatively charged color completely and only part of that positively charged. It is also known that freshly dissolved vegetable color, of which the Exeter water contained much, is not so readily coagulated as was the color dissolved from an old peat bog, and his idea was that chlorine might age the fresh color bodies by oxidation, or, as it was unscientifically expressed at the time, harden the vegetable matter so that it could be coagulated by alum.

We may now make a better explanation of this empirical process which works to save coagulant and wash water, to reduce the color of the effluent and also the accumulations of slime in the filter beds and to lengthen the period between washings. Apparently the addition of chlorine decreases the pH value without lowering the alkalinity and saturates organic compounds, changing their physical states, and thereby making them more easily precipitated by metallic hydrates.

There are many plants where this process might be used with advantage, especially those which treat waters of high vegetable and color contents. Chlorine treatment of these waters before coagulation would reduce the amounts of unsaturated organic compounds in the effluent, thereby reducing the liability to the formation of odors and tastes due to compounds between the organic matter in the effluent and the chlorine used to disinfect it after filtration.

Since the war, there has been a tendency to economize on coagulant, to be satisfied with a lower degree of color removal and to place more reliance upon chlorine to make the water safe for drinking. In some of these cases, complaints because of odors and tastes in the filtered water have arisen where no complaints arose during the period when larger doses of alum were used. In others, more effort has been required to keep the sand beds free from accumulations of organic matter. The writer therefore suggests that

the application of as much chlorine to the raw water as the organic matter will absorb, might effect a considerable saving in coagulant over that required to remove most of the color, besides greatly reducing the amount of organic matter remaining in the filtered water and readily combined with chlorine.

It would seem that the principal reason why chlorine has not been applied to the raw water more frequently is because more perfect disinfection can be obtained by the application of smaller doses of chlorine to the filter effluent. This is, of course, true and in some cases it is also true that more chlorine has been added to the raw water than the organic matter would absorb. It is generally true, however, that if a dose of chlorine only large enough to just saturate the organic matter be added to the raw water, the resulting effluent after treatment with alum and filtration, will contain much less organic matter than if pretreatment with chlorine were omitted, and furthermore, it will require less chlorine for disinfection than if none of this element were added to the raw water.

In reservoir waters treated with copper sulfate to kill algae, it is often wise to add chlorine before filtration to insure the destruction of the odoriferous compound set free at the death of the organism. Dr. Hale has employed this principle for treating waters which are not filtered, and it should be no less useful where filters are employed.

The empirical methods of water treatment are becoming antequated rapidly, but there are some who still cling to them. The work of members of this Association has demonstrated some of the conditions, especially ionic conditions, under which coagulation is at its optimum. Some of these are the presence of free carbon dioxide and a low pH value for a complete precipitation of aluminum hydrate and a high pH value to render effluents less corrosive. To these, in the writer's opinion, should be added the use of chlorine to oxidize or saturate certain organic compounds which otherwise are not readily coagulated by sulfate of alumina alone.

THE VALUE OF COMPREHENSIVE WATER SUPPLY INVESTIGATIONS[1]

By Alex Van Praag, Jr.[2]

Perhaps no one element is more directly responsible for the uneconomical operation and high maintenance costs, and the ultimate failure and abandonment of municipal waterworks stations, than is the failure to conduct a comprehensive and systematic study of the community's water resources prior to the construction of the waterworks system. By a comprehensive and systematic study of the community's water resources is meant a thorough knowledge of the available sources for a water supply development, together with a reasonable understanding of the possibilities of the chosen source of supply with respect to future extensions and enlargement; and also a complete analysis of the relative costs of developing the available sources of water supply, including operation and maintenance costs. The object of this paper is to discuss the value of such preliminary studies insofar as they apply to shallow ground water sources.

That an accusation of this character is based upon sound facts and is just is evidenced by the substantial number of municipalities which from time to time entirely abandon one source of supply in favor of a newly located source, not infrequently in close proximity to the original or former source of supply.

It is manifest, if the above mentioned preliminary studies are to be made, that one of the first and most vital determinations in the study is an assembly of the facts concerning the water bearing strata. Now, throughout certain sections of Illinois the nature of the geological structure is relatively well known and the records thereof are reasonably complete. For example, in most of our northern counties it is reasonably certain that an ample water supply of good quality is readily obtainable if wells are drilled to

[1] Presented before the Illinois Section meeting, March 21, 1923.

[2] Member of Holbrook, Warren, and Van Praag, Consulting Engineers, Millikin Building, Decatur, Ill.

St. Peter or Potsdam Sandstone. In such a case a preliminary study requires no extensive prospecting or test drilling to determine the local geological structure, but may be considered primarily, if not solely, for the purpose of ascertaining the type and probable cost of any proposed installation.

In other sections of Illinois, however, the prevailing conditions are decidedly different. In Central Illinois, for example, the major number of our public water supplies are derived from shallow ground sources, more generally from water bearing glacial drift deposits. The records of drillings in one community are of little, if any, value to a neighboring community, and in general the records themselves are very meager. Moreover, the glacial drift is peculiarly irregular and non-homogeneous and there is no certainty in securing any appreciable volume of water until extended drillings and pumping tests have been made. Under these conditions the preliminary studies in connection with a proposed water supply installation are of grave importance, for on their thoroughness depends not only the possibility of the installation from a financial standpoint, but the feasibility of any installation being made at all. Still further, the reliability and operating success and the cost of maintenance in such cases are entirely dependent upon the action taken as a result of the preliminary investigation.

All too frequently preliminary investigations of ground water supplies are not made at all or they are directed by the unqualified judgment of local persons in preference to being based upon an assembly and study of facts and data best interpreted by engineers experienced in water supply developments. It seems to be the general mistaken impression of public officials that the first available funds should be expended at once for a part of the necessary equipment for the waterworks instead of using the first modest expenditure for investigation to insure the water works installation being a permanent and economical one.

In order to elaborate somewhat on the necessity of preliminary studies and suitable test drillings the author assumes the liberty of referring to, and analyzing, the water supply history of a particular city with which he is personally familiar. It is one which presents a typical case.

Mt. Pulaski is a city of 1510 population. It is built upon the peak of an abrupt hill, one of a few high points in Central Illinois. The surrounding territory is quite flat and the nearest well defined watercourse is approximately $3\frac{1}{2}$ miles distant.

The original waterworks at Mt. Pulaski were installed in 1895 and the source of supply then comprised a single well about 85 feet in depth, penetrating fine sand, and located at the public square on the very peak of the hill. About 1907, only twelve years later, a new waterworks station was constructed in the southwest part of the city, the supply then being derived from three dug wells, penetrating a layer of fine yellow sand of more or less indefinite depth. Each well was 33 feet in depth and was walled with stone. These three wells which are still in service are all located on a single tract of land enclosing about three-quarters of an acre. Another similar well, but with a 23 foot tubular extension in its bottom, was also located nearby and formerly was held in reserve to meet excessive demands, though it later was entirely discarded as a part of the public water supply.

Since their construction these wells have ever been subject to clogging with fine sand thereby reducing their capacities, causing undue wear on pumping equipment, and resulting in exorbitant maintenance costs. Their yields have accordingly been totally inadequate and the cause of a general restricted use of water. The restricted use of water has resulted in a general tendency to depend upon private wells, all of which circumstances, of course, assist in raising the unit operating costs of the public supply.

For some time the city council has realized the necessity of improving the city's water supply resources and during the past year it was prevailed upon by its engineers to conduct a series of test drillings in the hope of locating a more satisfactory source of supply.

The engineers outlined a systematic program of drilling based upon a study of the surrounding topography, assembled records of previous drillings, and a knowledge of the general geological structure in the vicinity, and the drilling program was instituted.

A series of holes were drilled progressively to the east and south along a more or less meandering line lying just south of the city, where the available data indicated a satisfactory supply was most likely to be located. As each test well was drilled samples of the drillings were collected for examination and accurate logs of the wells were drawn. The logs were platted in section to their true elevation along sections drawn through the principal lines of the drill holes, and an accurate plat was made showing the location of each test hole. These data not only served their purpose, during the progress of the drillings, but are now a matter of permanent record.

A total of 22 test holes were drilled before a supply of satisfactory volume was located and the final location determined for a new pumping station. As a result of the drillings, however, the city has located a water bearing stratum consisting of coarse sand and clean coarse blue gravel approximately 17.5 feet in depth and lying between depths of 40 and 57.5 feet below the surface. The deposit is under a static head of water which rises to within 14 feet of the surface.

Before concluding the test drillings the city conducted a pumping test on a 8 inch well located at the site of one of the test drillings. The test was conducted under the direction of the engineers assisted by representatives of the Illinois State Water Survey and the State Department of Public Health. It included a continuous pumping of the well for about 26 hours, during which time measurements of the well discharge and of the draw-down, both at the well itself and at other nearby points, were simultaneously recorded. It should be noted that, while the drawdown when first pumping the well was marked and rapid, yet with continued pumping the water level gradually assumed a more or less permanent level and at no time was it lowered to the top of the water bearing stratum.

The test data secured indicate that the city can produce from a single well in the vicinity a sufficient supply of water to satisfy its present demand with less than six hours of continuous pumping. Heretofore, the present wells have been exhausted after a relatively short period of pumping and it became necessary to discontinue pumping until they again were replenished, and the supply accordingly has been extremely doubtful at all times.

The total cost to the city for conducting the test drillings approximated $1500 and the city is now having prepared the necessary plans and specifications for a new pumping station. This new pumping station will probably be constructed during the coming year. It makes the third water pumping station to be constructed in a period of twenty-eight years. It is 16 years since the construction of the present station.

It should not be assumed that the Mt. Pulaski stituation is an unusual one and that it did not offer its difficulties during the period of the drilling. As a matter of fact, it was necessary at the outset, in order to satisfy certain members of the city council, to drill two holes on the present pumping station lot. Both of these holes were drilled to more than twice the depth of the present dug wells and

each penetrated but a negligible depth of fine yellow sand, water bearing, and thus showed conclusively that the present location is a most unsatisfactory one.

After sinking some 7 or 8 holes with only moderate success, the city against the advice of its engineers again returned to the present water works site and sunk in the immediate vicinity at least two more holes.

During the course of the drilling it was necessary also to satisfy the demands of certain council members who have a religious belief in the unfailing "water witch." These particular members, it is interesting to note, were able by the use of the "witch" to trace the water bearing strata from one of the test hole locations, after the test hole had been drilled, for a distance of nearly 150 feet towards the old pumping station site. At this point they were forced to discontinue the use of the witch because of severe cold weather and unfortunately the weather has not as yet sufficiently moderated to permit their again bringing out the "witch" for further service.

Now it should be noted that at Mt. Pulaski there were no visible or outstanding assurances of success in locating a satisfactory water supply if the test holes were sunk, excepting the convictions of the engineers who had devoted some time and study to the local situation. To be sure, many of the first holes sunk indicated discouraging results and it was not until the entire 22 holes were sunk that conditions were considered satisfactory to warrant discontinuing further investigations. On the other hand in a similar study at Witt, Illinois, it was found necessary to sink only 5 holes when sufficient data were secured to warrant discontinuing drilling.

It is not of general interest that Mt. Pulaski has experienced particular success in improving its water supply by drilling. The Mt. Pulaski experience is discussed here because it is a typical experience and illustrates the one point the author wished to impress, that is, by a modest expenditure for test drillings and preliminary investigations and by truly studying its water supply resources this city has located a source of water supply sufficient to warrant the abandonment of its present supply in favor of a new one. Had this new supply been properly investigated before the preceding two water pumping stations were installed, it would doubtless have made unnecessary the large expenditure for rebuilding at least twice and would have eliminated largely the relatively exorbitant maintenance costs which have been experienced by the city

for the past 28 years. Many other cities have had much the same history as Mt. Pulaski. Not until the value of thorough preliminary studies is fully appreciated, however, may we expect to eliminate this needless waste of money on waterworks improvements.

As engineers or persons otherwise interested in the proper development of public water supplies it remains with us to exert every effort to assure that future water supply installations will be based upon sound facts and not upon chance judgment. In other words, if we wish to insure proper and economical water supply installations and assist in preventing expensive rebuilding programs, we must impress the responsible officials with the necessity of comprehensive and systematic preliminary water supply investigations by competent engineers.

DISCUSSION

Mr. S. L. Etnyre:[3] I should like to ask Mr. Van Praag what conclusions he drew from the drop of water in the well and the relative drop in well and the test hole (about 150 feet distant) as to the size and adequacy of the underground reservoir supply.

I wish to cite a very remarkable well system in South Omaha, Neb. The South Omaha Stock Yards Company decided to build a water plant of its own and found a very excellent grade of water in the Missouri River bottoms quite near to the river. Tests on a pumpage of about 300,000 gallons per day showed the water level to drop 65 feet during the first hour, but very little drop thereafter. The total quantity of water desired being 4,000,000 gallons per day fifteen 10 inch wells were driven within an area of several acres, and it was found that the water level dropped about the same when pumping from all the wells as from the single well.

Mr. Alex Van Praag, Jr.:[2] When a water supply is derived from wells it is manifestly impossible to conduct a detailed physical inspection of the source of supply to determine its adequacy. We must accordingly resort to the best available known means for determining such data. In the case of a shallow well supply, the two fundamental elements in determining the adequacy are, first; a determination of the storage volume of the water bearing strata, and second; an understanding of the source and manner of replenishing the available storage and its ability to replenish the demands made upon the storage reservoir. The former element may be satisfac-

[3] Superintendent, Water Works, Council Bluffs, Iowa.

torily determined by conducting extensive drillings to locate the limits of the water bearing strata and by examining the character of the water bearing strata to determine their volume of voids. The latter element, in the case of a shallow ground water source, is substantially dependent upon the rainfall and the watershed area above the well locations, which factors are relatively easily determined. These data, substantiated by a study of the results of an extended pumping test, afford the best known means of determining a supply's adequacy.

In the case of Mt. Pulaski we conducted a series of test drillings and we had a fair knowledge of the limits of the water bearing stratum and its character and accordingly we calculated its probable storage capacity as being far in excess of the demand between periods of replenishment. We also knew that the watershed area above the wells was a considerable number of square miles and was amply able to replenish the storage basin from year to year with ordinary percolation from the rainfall over the watershed area. In addition to this we conducted an extended pumping test following a period of drought and after a few hours pumping we were unable appreciably to alter the water level in the well, indicating that continuous pumping at the rate necessary to supply the city's demands had little affect, if any, upon the vast storage volume available.

These data, gathered by the best known available means of determining a well water supply's adequacy, we believe justify our conclusion that the proposed new supply will be adequate.

THE WATERS OF NORTH DAKOTA

By A. E. McCoy[1]

At various times numerous calls have been received in the Public Health Laboratory for data upon that very interesting subject, the water supply of North Dakota. An immense amount of material has been accumulated during the period these laboratories have been in operation. Perhaps the most work done was by Dr. Gustav F. Ruediger during his term of office as Director of laboratories and the material he collected has been used, together with a great deal of data accumulated since, in the preparation of this paper.

The rivers of the state contain a palatable water and need very little treatment to render them quite safe for drinking purposes, but most of them are very hard. The same cannot be said of the well waters. Throughout the whole of the state, shallow wells, none deeper than 20 feet, yield a fairly palatable water, but artesian and deep wells, as a rule, yield a highly mineralized water. In order to find a standard with which to compare the waters of this state and to decide which is a good water and which is the opposite, the standard fixed by the Secretary of the Treasury for the chemical purity of waters used on interstate trains has been adopted. The amounts are expressed in parts per million and can be converted into grains per gallon by multiplying by 0.058:

	GOOD	FAIR	POOR	BAD
Total solids	Up to 1,000	Up to 1,500	Up to 2,000	Any-
Chlorine	Up to 250	Up to 800	Up to 1,200	thing
Sulphate radicle	Up to 250	Up to 600	Up to 1,000	over
Magnesium	Up to 75	Up to 125	Up to 175	these
Carbonates	Up to 50	Up to 100	Up to 250	figures
Alkalinity	Up to 500	Up to 800	Up to 1,200	

Many of the waters placed in the "fair" class or in the "poor" class have only a temporary effect upon the people using them and

[1] Formerly Chemist, State Public Health Laboratories, North Dakota. Deceased.

the body soon develops a tolerance for them. Stock which has been reared on such water is slow to drink water which is in the "good" class. At the same time, however, horses are said to suffer various disorders when subjected to waters with high chlorine and sulphate content. When selecting a water for municipal supply every effort should be made to find one that meets all requirements for the class called "good" and does not have a hardness exceeding 400 parts per million. Its bacterial content should also be considered, for, while the water may pass muster chemically, if it be above standard bacteriologically, the cost of treatment has to be considered.

The suitability of a water for boiler use has also to be considered. It has been found that there are no good, untreated, boiler waters in the state, the porportion of lime, magnesium or iron being so high that the formation of incrustants renders them very unsuitable. For this reason the Great Northern has installed water softening plants throughout its lines from Devils Lake west.

The artesian wells in the Red River Valley yield water that is quite salty to the taste and very hard. Practically every water analyzed contains more than 2000 parts per million of total solids and over 1200 parts of chlorine. These waters are used for every purpose apparently without bad effects. The deep wells, which do not flow, often contain very good water especially in Cass and Richland counties.

The shallow well water of the Red River Valley is, as a rule, less highly impregnated with mineral salts than that of the deep wells, except perhaps, in the northern part of the state, where throughout Pembina, Cavalier, Walsh and again in Trail counties the underground shallow wells are quite salty in taste. If the soil is sandy the waters may have a hardness of 500 parts or less, but their bacterial count is likely to be high, especially if the wells are not properly protected. The shallow well waters classed as "bad" contain large amounts of Epsom salts which give the water a bitter taste and are irritating to the intestine.

The deep well waters in the central plains are somewhat better than those in the Red River Valley, being lower in solids, hardness, and sulphates but higher in alkalinity. Even at that, however, they are considerably above what is considered a suitable water. The flowing wells are not very common except in the southern tier of counties. The wells here are very deep and the waters highly mineralized and uniformly hard. All are very high in sulphate or

chloride. The shallow wells of this region are softer and lower in magnesium compounds than those of Red River Valley, but, when compared with the deep well waters, they are harder and higher in magnesium salts. The best shallow wells are found in Pierce, Benson and Nelson counties.

In the western part of the state, or Missouri plateau region, flowing wells are very scarce except at the north and south borders of the county. These waters are very soft, but have a high alkalinity due to bicarbonates. The deep well waters are also high in alkalinity and have a high mineral content and can be used with some satisfaction as boiler supply.

Compared with the deep well waters of the Red River Valley they have a higher alkalinity and are more highly mineralized, but have not such a great degree of hardness. Compared with those in the central part of the state they have a higher alkalinity and hardness content, but not so much chlorine or sulphates.

The shallow wells in this part of the state are the least mineralized of anywhere and for this reason may be classed as good boiler waters.

To go into the subject a little more particulary, the records of chemical analyses made at the main office of the Public Health Laboratories have been gone over and the results of 96 examinations made from January 1, 1917, to February 14, 1920, have been studied.

The principal visible water supply of the Red River Valley is the Red River. This source is used by Wahpeton and Fargo and as an auxiliary supply for Grand Forks. The water, owing to its hardness, turbidity and high pollution is softened, settled and chlorinated. The Fargo analysis may be taken as an example:

Total solids	179
Alkalinity	113
Chlorine	7
Sulphates	31
Carbonates	32
Magnesium	97

Comparison with our standard shows that this water contains too high a hardness radicle. It is interesting to compare also the water of the Goose River used by Mayville:

Total solids	918
Alkalinity	251

Chlorine	26
Sulphates	390
Carbonates	251
Magnesium	390

This water, owing to its high mineral content, is practically unfit for any purpose whatever. Even plumbing fixtures are attacked.

Nine well waters of varying depths have been examined, which have been scattered throughout this region. It is difficult to single out any one as distinctive for the region as they vary so much in total solids, chlorine content and hardness. However, we will give the figures for a well at Drayton:

Total solids	20,922
Alkalinity	236
Chlorine	9,384
Sulphates	988
Carbonates	23
Magnesium	256

and the well in the park at Mayville:

Total solids	3,362
Alkalinity	219.3
Chlorine	773.7
Sulphates	649.8
Carbonates	568.6
Magnesium	281.2

All these waters are high in sulphates, alkalinity and magnesium compounds. They have more or less of a "salty" taste and are high in incrustants.

Of waters from the central plains some 18 localities have contributed 38 samples. These are all well waters, many being taken from several sources in one locality in an endeavor to find the most suitable supply for a waterworks installation. The latter samples being from Jamestown, Langdon, Lakota, Leeds, Fessenden and New Rockford, which furnish rather a good selection for comparison. A study of the average analysis of 4 samples of Jamestown water taken from different wells shows the following:

Total solids	754
Alkalinity	359
Chlorine	42
Sulphates	421
Carbonates	105.8
Magnesium	179.2

Comparing this with our standard we see that the mineral content puts these samples in the "fair" class, if not in the "poor." Going to the opposite end of the state we may examine the Langdon waters where some 10 samples were tested to determine which would yield the most suitable water for a city supply. The average of the analyses is as follows:

Total solids	1,157
Alkalinity	266.5
Chlorine	177.8
Sulphates	379.6
Carbonates	132.8
Magnesium	80.2

Comparison with our table shows this to be a fairly good water. In fact the water in use now at Langdon is of good quality, but contains enough iron to cause a noticeable taste and odor when it stands in the pipes or is heated.

It might also be interesting in this connection to consider the water as found at Fessenden, which is placed in about the centre of this section of the state. In searching for a satisfactory water supply for this city 5 representative samples were examined. These yielded results as follows:

Total solids	1,342
Alkalinity	540.5
Chlorine	182.3
Sulphates	340.3
Carbonates	284.2
Magnesium	51.2

The waters from this region, therefore, can be placed in the "good" class, except that they need softening. It is difficult however to say positively just how each of the many samples in this region compare with each other, but the northern group of waters, while very "salty" in taste, and so unfit for drinking, are often quite soft.

In the Missouri Plateau section, beside some 24 wells, we should consider also the Missouri river which is used by Williston, Mandan and Bismarck. The water from this source is very turbid and highly polluted so that these cities have installed complete treatment plants, such as sedimentation, chemical treatment, filtration, (except Bismarck and Mandan) and chlorination. The untreated river water in several examinations taken at Williston and Bismarck usually tests as follows:

Total solids	662
Alkalinity	368
Chlorine	29
Sulphates	161
Carbonates	125
Magnesium	164

This shows that the river water is of moderate hardness and can be made a very suitable source of supply.

The well waters of this region are more or less colored with vegetable matter owing to the whole district being underlayed with lignite deposits. Several of the wells yield a coal black water which when treated with a coagulant, is quite satisfactory. Such a water is found at Scranton in Bowman county in the southwest corner of the state. Seven samples of varying duskiness have been analysed from this town with the results as follows:

Total solids	1,253
Alkalinity	453.1
Chlorine	22.4
Sulphates	417.8
Carbonates	318
Magnesium	157.1

This places these waters in the "fair" column, but shows them inclined to be hard.

The waters in the northern part of this section should next be considered and these comprise samples from Crosby, Berthold, Minot, Kenmare and Stanley. A synopsis of these analyses is as follows:

Total solids	2147.1
Alkalinity	709.7
Chlorine	38.4
Sulphates	625.2
Carbonates	625.3
Magnesium	142.1

It will be noticed that these waters come in the "poor" class, which is all too true with the exception, perhaps, of Minot. Here we have a water that has some color and a pleasantly salty taste, but is of very good quality otherwise and one of the two city wells is quite "soft." All these samples contain iron in such quantities as to stain porcelain or enamel ware.

TABLE 1

PLACE	POPULATION	WATER SYSTEM	SOURCE SUPPLY	TREATED	STAND PIPE	DIRECT PUMPAGE	GALLONS USED PER DAY IN THOUSANDS	SEWER SYSTEM	STORM SEWER SEPARATE	SEWAGE TREATED	METHOD	PER CENT POPULATION SERVED
Anamoose	700	Yes	Well	No	Yes	Yes	10	Yes	No	No	†	32
Bismarck	7,161	Yes	River	Yes	No	Yes	500	Yes	No	No	†	50
Carrington	1,500	Yes	Well	No	Yes	Yes	?	Yes	Yes	Yes	Septic tank	60
Devils lake	5,200	Yes	Well	No	Yes	Yes	250	Yes	No	Yes	Septic tank†	50
Dickinson	4,100	Yes	7 wells	No	Yes	Yes	175	Yes	No	Yes	Septic tank†	65
Enderlin	1,919	Yes	3 wells	No	Yes	Gravity	50	Yes	No	Yes	Septic tank†	65
Fargo	23,000	Yes	River	Yes	No	Yes	2,300	Yes	No	No	†	90
Grand Forks	14,000	Yes	River	Yes	No	Yes	890	Yes	No	No	†	90
Grafton	2,500	Yes	Well	No	Yes	Yes	?	Yes	No	Yes	Septic tank	75
Garrison	714	Yes	2 wells	No	Yes	Yes	?	Yes	No	No	†	83
Hillsboro	1,183	Yes	Well	No	Yes	Yes	6	Yes	No	No	†	50
Hazen	600	Yes	Well	No	Yes	Yes	?	Yes	Yes	Yes	Chemical†	10
Harvey	1,492	Yes	River	No	Yes	Yes	60	Yes	No	No	†	25*
Jamestown	6,627	Yes	Well	No	Yes	Yes	450	Yes	No	Yes	Septic tank†	75
Kenmare	1,543	Yes	Well	No	Yes	Yes	?	Yes	No	No	†	66
Larimore	1,039	Yes	Well	No	Yes	Yes	?	Yes	No	No	†	30
Lidgerwood	1,100	Yes	6 wells	No	No	Yes	?	Yes	No	Yes	Septic tank†	100
Langdon	1,228	Yes	2 wells	No	Yes	Yes	20	Yes	No	No	†	75
LaMoure	1,009	Yes	Well	No	Yes	Yes	50	Yes	No	No	†	95
Lisbon	1,655	Yes	5 wells	No	Yes	Yes	30	Yes	No	No	†	80

Mayville	1,218	Yes	River	No	Yes	Yes	70	Yes	No	Yes	Cess pool†	50*
Marmarth	1,460	Yes	2 wells	No	Yes	Yes	20	Yes	No	No	*†	65
Mandan	3,873	Yes	River	Yes	No	No	133	Yes	Yes	No	†	75
Minot	12,000	Yes	2 wells	No	Yes	Yes	300	Yes	Yes	Yes	Filter beds†	80
New Rockford	2,200	Yes	4 wells	Softened only	Yes	No	50	Yes	No	Yes	Septic tank†	40
Oakes	1,637	Yes	18 wells	No	No	Yes	166	Yes	No	No	†	95
Stanley	591	Yes	2 wells	No	Yes	Yes	5	Yes	Yes	No	†	40
Velva	835	Yes	Springs	No	Reservoir	Yes	30	Yes	No	No	†	80
Valley City	5,136	Yes	Well	No	Yes	Yes	265	Yes	No	No	†	85
Williston	4,278	Yes	River	Yes	Yes	Yes	?	Yes	No	No	†	98
Wilton	1,025	Yes	4 wells	No	Yes	Yes	25	Yes	No	No		25
Wahpeton	3,000	Yes	River	Yes	Yes	Yes	300	Yes	No	No	†	100
Cooperstown	1,019	Yes	Well	No	Yes	Yes	?	Yes	No	Yes	Septic tank	Just completed
Hankinson	1,503	Yes	2 wells	No	Yes	Yes	?	Yes	No	Yes	Septic tank	Under construction.
Leeds	682	Yes	Well	No	Yes	Yes	10	Yes				Just completed†
McVille	350	Yes	Well	No	Yes	Yes	10	Yes	No	Yes	Septic tank†	Just completed

*Not used for drinking.

†Discharge into river, wet coulee or lake.

This report would not be complete without reference being made to the spring waters. These are located in Grand Forks, Trail and Stutsman counties together with a group along the Missouri slope (7 samples in all). Springs occur at Inkster, Northwood, Hatton in Grand Forks county and, with perhaps one exception, yield a very good sample of water from a chemical standpoint. The springs near New Rockford and at Jamestown also yield excellent water. Three springs near Williston, recently examined, are also found to be in the "good" class.

The Federal Government is conducting an investigation into the question of "stream pollution" and on the receipt of a request from Mr. R. E. Tarbett, Associate Sanitary Engineer, United States Public Health Service, a questionnaire was sent out to all the cities and towns in the state possessing water and sewer systems to ascertain what disposal was made of sewage in this state. Replies were received from thirty-six points. These have been arranged in table 1.

A study of this table shows only 9 places which get their water from a visible source, 8 from rivers and 1 from springs. Six of the 8 river supplies are treated with a coagulant and chlorine, the other 2 use the water for sanitary purposes only, while water for drinking, washing clothes and cooking is obtained from melted ice, cisterns or shallow wells:

In regard to sewage disposal, 27 discharge their sewage into the river, lake or coulee untreated, 9 give a preliminary treatment with some form of septic tank. Only 1 city in the state, Minot, has installed a modern sewage treatment plant and this was in operation in the summer of 1921. The other places discharge into a low place or dry coulee.

Some attempt is made to soften the river water in Fargo and Grand Forks. New Rockford has just installed a softener for its well water supply and Mayville is considering such an improvement.

In conclusion, it may be said that, while some attempt is made to prevent stream pollution, our larger cities, except one, are doing nothing in that respect. It will be only a matter of time before they will be compelled by law to abate the nuisance which their untreated sewage will create for communities situated below them.

THE CONDITION OF THE MINOR PUBLIC WATER SUPPLIES IN IOWA[1]

By H. V. Pedersen[2]

Whenever any one starts out to put the blame of something on somebody, he immediately lays himself wide open to criticism. It is not my intention however to pick out only the worst conditions and then blame certain individuals for them. It is my intention to discuss in a general way the conditions, both good and bad, and to point out the possible reasons why these conditions exist.

There are approximately 900 incorporated cities and towns in the state of Iowa. Of these, 15 belong to the first class, 92 to the second, leaving approximately 800 that may be put into a third class. Out of this total of 800 third class towns only 400 have public water supplies, which we here classify among the minor water supplies of the state. It may be well to remark here that there are still over 400 incorporated towns in Iowa that have no form whatever of public water system.

These small town public utilities, commonly known as a water works system, are composed, as all systems are, of two factors. The one factor is the distribution system, consisting of pumps, pumphouse, water mains and storage or pressure reservoirs. The other factor is the water that is distributed through the distribution system and the source from which that water is obtained. The one factor is as essential and important to a good water system as the other, for what good is a distribution system to a community unless there is a good supply of water available, or available water with no means of distributing it to the consumer or within reach of the home or business in time of fire? But regardless of how self-evident this seems, inspection of more than 100 of these systems during the past year by the Engineering Department of the State Board of Health has disclosed the fact that there is much room for criticism against certain past practices in the state.

[1] Presented before the Iowa Section meeting, November 2, 1922.

[2] Sanitary Engineer, State Board of Health, Iowa.

In practically every place visited some fault could be found with or some criticism be made of the distribution system. Some towns have outgrown the 4 inch main service and are suffering from inability to bring enough water to a certain place in town in time of fires. Other towns suffer from lack of storage capacity, some from poorly constructed, open reservoirs, and the majority most of all from some poor piece of construction which allows surface pollution to enter the water.

A great deal might be written on the subject of proper size of water mains for minor systems. Fire insurance companies demand more use of 6 inch pipe while past practice has specified very little of that size. There is no question but that some engineers or corporation installing water works systems have in the past placed many miles of 4 inch pipe where 6 should have been laid. No doubt the towns themselves are somewhat to blame as they wished to cut down first costs. No matter who is to blame or what the past theory was, however, it is certain that more thought must be given to the use of 6 inch pipe and the difference in initial cost of the 4 and 6 inch pipe must not be taken into consideration.

Most small towns in Iowa have ample pressure for fire fighting, as the majority of them have elevated steel tower tanks. In some places the tanks are a little too small, but with constant pumping this difficulty is overcome. Some have old pump equipment and old dark, dingy pump houses that need replacing, but, on the whole, without taking the lack of duplication into consideration, the equipment of our minor water supplies is satisfactory. They are not all perfect, although generally they "get by"! The one outstanding feature to be criticised in most of the water works systems is not so much the equipment of the distribution system as the failure to protect the water supply.

The consensus of opinion among many people directly concerned has appeared to be, or you might say that it has been the policy in the past of town officials and engineers, that, if you get a distribution system installed to distribute water, the source of supply will take care of itself. More stress has been and is still being put on the distribution system than upon the supply of water. Much of this opinion is due to the fact that the public and many engineers have failed to take the matter of a safe water supply seriously.

It may seem a little exaggerated to many, but it is a fact that about one-half of the minor water supplies in the state are unsatisfactory.

The majority of these unsatisfactory supplies are shallow wells, although there are a goodly number of deep, drilled wells included which are from 20 to 50 years old. Years ago when these supplies were chosen it was not difficult to get an ample flow of safe water almost anywhere. A well could be sunk and if there was any water at all, that water would most probably be free from surface contamination. Today the location and construction of a well supplying water to our smaller towns is a most serious problem.

One minor supply after another is being reported as unsafe for drinking purposes, when the bacteriological analyses disclose the fact that the water is contaminated by surface pollution. Of all the public water supplies visited by the Engineering Department, where the B. coli group of bacteria were found, it was invariably discovered that the wells were located in the lowest point in the town, where all of the natural drainage may easily contaminate the water. Many towns, which for years prided themselves upon their excellent water supply, are being most heartlessly awakened to the fact that they no longer possess the best water in the state, but that the wells are polluted by surface contamination, are located in entirely the wrong place and, if they continue using the supply without shutting off this contamination, they are subjecting themselves to a greater risk of water born diseases than is desirable.

But if these are the prevailing conditions, who is to blame? In my opinion, I should say that we are all to blame. We have all been too busy talking about the systems in our larger cities and about purification plants and so on and have failed to give much thought to what the smaller communities have. Every engineer in the state, every manager or operator of a water plant, every member of this organization must be made to realize that the problem of securing a safe drinking water in Iowa is becoming more and more serious. Every engineer or corporation that has made a business of designing water works systems should give more thought in the future to the water supplies. Every engineer or water plant operator should impress upon the community that is employing them the importance of first locating a good and safe water supply. If a town is contemplating a water system and has only a limited amount of funds, it is better to spend it on obtaining a good water supply and a portion of a distribution system than to spend it all for a distribution system and have a water supply that is not fit for drinking. All towns with water systems which are having trouble with their water

supplies should be urged, when it becomes necessary to abandon the old supply, not to make the same mistake twice and to locate on a new site that is as bad as the old one.

Often careful thought and experiment are required to determine whether it is best to drill a deep well, to depend on shallow ones, or to use wells at all. Each locality has its own characteristics and difficulties. What might be the best for one town might be entirely wrong for another. The geological formation of Iowa and the mineral deposits are such that no two districts can be treated alike. Because a town in northern Iowa has a good deep well is no reason why a town in southern Iowa should spend all of its money trying to drill one. Every one who has anything to do with water or who claims to know anything about it should urge upon every community the necessity of studying every possible source of water, before a permanent site is definitely decided upon, that a water supply should be chosen only after taking both quantity and quality into consideration, that if two supplies are available and one contains less iron, less sulphate or is less hard than the other, that supply should be given more consideration, even if it is located several miles from the town. There is absolutely no excuse for putting any new well in an improper location.

When making surveys of public water supplies we hear many expressions of how the water has been good for years and years and they cannot understand why it should be bad now. The general public is somewhat confused on the subject of pollution and has been told so many things that it hardly knows what to believe. Even engineers do not all agree on the theory of underground water pollution. Some say that bacteria from seeping privies, barnyards and other sources will pass for long distances through water bearing sands when once they enter it, while other engineers believe this is untrue. I am not going to discuss the problem of underground pollution at this time. However, all engineers and water works men should advocate that all precautions should be taken to locate a water supply and protect the pump installations and valve connections so as to exclude surface waters, since we know that all surface waters of Iowa are more or less polluted and contain bacteria of a dangerous nature.

As the Engineering Department of the State Board of Health is, in a way, the guardian of the water supplies of the state, you no doubt wish to ask what we are doing to better conditions. We are

trying to better conditions, but the department is so small and has so little money to spend that it is impossible to make even a fair showing. Along with the required routine work of the office, it is only possible to investigate about 100 water supplies a year. At this rate it would take five years to cover the state. This year we have so many other things to do in the work of sanitation that it will not be possible even to visit this many. You can all realize that many things may happen to a water supply within 5 or 6 years.

So far, the general public of the state of Iowa, various organizations and the members of the engineering professsion have failed to realize the seriousness of state supervision of the public water supplies and have failed to demand that the state legislature provide such supervision. Several states adjoining Iowa have a division of sanitation with a staff consisting of a chief engineer, 4 or 5 engineering assistants and sufficient office help to carry on the work properly. Iowa, one of the wealthiest states in the union, provides only one engineer and one stenographer to do all of the work of sanitation in the state.

As the sanitary engineer of the state, I wish to urge you men here to give as much thought in the future to the conditions of our minor supplies as you have to the major and that you use your influence in every community with which you come in contact to cause the true facts to be known. The public should demand the proper sanitary protection to which it is entitled.

THE AMES, IOWA, WATER SUPPLY[1]

By P. F. Hopkins[2]

The City of Ames, Iowa, derives its water supply from a thirty foot sand and gravel stratum, lying between the depths of seventy-five and one hundred and five feet below the normal ground surface. The water is organically pure and is satisfactory as a city supply, except that it is somewhat hard—about 16 grains—and carries a high iron content. At the present time the water is aerated, but adequate storage is not available to give detention period sufficient to settle out the iron. Consequently, this settlement takes place in the mains and results in annoying discoloration whenever any unusual disturbance occurs in the mains. Frequent flushing helps, but the relief is only temporary. No treatment other than the aeration is given the water. It is tested on Tuesday and Thursday of each week and is always found satisfactory. Occasionally the Bacteria aerogenes show up, but the irregularity with which this occurs indicates contamination from some source after the water has left the ground. With the iron removed, the water would be entirely satisfactory as a supply, and its accessibility and abundance make the consideration of any other supply unnecessary.

It is not, therefore, the supply itself that is causing the city administration concern, but rather the inadequacy of the wells, storage, and distribution system. The rapid growth of the city in the past few years has necessitated heavy outlay for new mains, hydrants, valves, meters, etc., all of which have been financed from the earnings of the plant, so that the ever increasing discrepancy between the demand and the storage, while not entirely overlooked, was at least neglected. Certain incidents have impressed on those directly in charge of the water supply the absolute and immediate need of strengthening the system, and in April, 1923, a special election was called to vote a $70,000 bond issue to carry out the needed extensions.

This election was peculiar in that it carried by an overwhelming

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] City Manager of Engineering, Ames, Iowa.

majority and yet failed—the vote being 1405 affirmative and 44 negative. The factor which was responsible for the failure was the statute which requires such bond issues to have an affirmative vote equal to a majority of all votes cast at the last general city election. It so happened that the "Sunday Movie" question had been an issue at the last election and a record vote of 2835 votes had been cast. The ordinary city election would hardly bring out more than 700 to 800 votes. There never was any fear of the negative votes—just a plain question of getting the people sufficiently interested in their dire need to go to the polls. This we were not able to do although every means of publicity was exhausted. It seems as though as long as a man finds water at his tap whenever he wants it, it is almost impossible to shake his childlike faith that somebody, somehow, will always see that he does have water. Tell him the facts and show him what might happen in case of a failure of the supply, and he will say: "Yes, yes, we must do something at once," but on election day he is busy, or he forgot to register, or some other reason or excuse prevents him voting.

Water for the downtown section, embracing the first three wards, is furnished from the city plant located in the eastern part of the city; water for the fourth ward, the section lying south and west of Iowa State College, is purchased from the College and distributed by the city. The College, being in about the same situation as the city as regards its water supply, has asked for several years that the city take over the fourth ward supply, and provision for this was included in the proposed extensions.

Two general methods were considered in connection with the fourth ward water; providing wells, storage, etc., in the fourth ward and operating it as a separate system, or interconnecting the two sytems and supplying all water from the down town plant. This second plan was adopted for the following reasons: (1) connecting the two systems would make the entire supply of the city and college available in emergency for the whole city and the College, (2) the source of the supply being the same for both sections makes the iron removal a necessity, and one plant would be more economical than two, both in first cost and in operation, (3) simplified operation, as the down town plant is operated in conjunction with the municipally owned light plant.

The down town demand varies from 350,000 to 500,000 gallons per day, the greatest demand coming during the summer months;

the fourth ward usuage is fairly constant at from 175,000 to 200,000 gallons per day, the summer demand being offset during the winter months by the presence of large numbers of students who are pretty well concentrated in the fourth ward. The average daily demand, then, for the whole city is at present around 600,000 gallons.

The present down town plant consists of two twelve inch wells, having a combined capacity of about 600 gallons per min., or about 850,000 gallon per day, a 100,000 gallons concrete storage reservoir, a 50,000 gallon elevated steel tank, two centrifugal service pumps having a combined capacity of 1000 gallons per min., and a 1000 gallons per min. steam driven Underwriters fire pump. The well pumps and service pumps are motor driven. It is readily seen that the storage, even for the down town section alone, is ridiculously inadequate, being less than a half day's supply.

The plan proposed for the extension embraces the following: (1) one additional well of 1000 gal. per min. capacity, (2) a concrete reservoir of about 800,000 gallons capacity, preceded by rather elaborate aeration, some chemical feed and a long mixing chamber travel, all intended to hasten the precipitation of the iron, and with provision for following the reservoir with filters as soon as finances would permit, (3) an additional service pump, (4) a booster station located near Squaw Creek and Lincoln Way, and a connecting main to the fourth ward system, (5) a 150,000 gallon elevated steel tank in the fourth ward, (6) considerable additional mains in the fourth ward, required to strengthen that system and cut down friction losses between booster pumps and elevated tank.

The booster station is required because the general elevation of the fourth ward is somewhat higher than the eastern portion of the city, and because some of the four story buildings in the fourth ward are situated on the highest ground. The booster pumps will be in duplicate, motor driven and of 500 gals. per min. each, so arranged that they may be operated in series, giving fire pressure if desired. They will operate automatically, being controlled by the variation in pressure on the discharge side of the pumps. A by-pass line provided with a check valve will insure a constant supply of water to the fourth ward, in case the booster pumps failed, although the pressure would be only that provided by the down town system. A second by-pass line will permit the backing in of the fourth ward reserve and the College supply in case of emergency. In other words, instead of the present 150,000 gallons storage available for the down

town section, there will be 1,100,000 plus the 400,000 gallons College supply, or 1,500,000 gallons, ten times the present storage.

The financial condition of the Department is good, the system having a conservative valuation of $150,000 with a bonded indebtedness of $35,000, and $12,000 cash on hand to take care of main extensions. All extensions are being financed from the plant's earnings. Since Jan. 1, 1921, six miles of mains have been laid, thirty hydrants added, and over 300 new meters installed. Mains are being laid at the rate of about three miles per year, with a mile and a half of pipes on hand to be laid yet this fall. We now have 24 miles of mains, 160 hydrants, and over 1800 services, all metered. It is intended to provide the new well this winter, as the emergency is too great to risk longer delay.

No trouble is anticipated in carrying the bond issue after next spring election, as the prople have had an impressive lesson in what lack of interest can do. No increased levy will be made to finance the bonds. All that is being asked is simply their authorization.

SOME PROBLEMS OF CEDAR RAPIDS WATER WORKS[1]

By H. F. Blomquist[2]

The problems of the Cedar Rapids Water Works are not unlike those that come at intervals to any other water works. The increase in the urban population together with changes in the standards of living have brought about increasing demands both in quantity and quality of the public water supplies in all cities. Water works are generally able to meet the increased demands by piece-meal additions to the supply and equipment for various periods of time, but ultimately, under ordinary conditions, a time comes when further piece-meal additions become uneconomical and impractical, and sometimes impossible.

In a decade the population of Cedar Rapids has increased 38 per cent, and in the same period the water consumption has increased 41 per cent, although during the same period the percentage of metered services was increased to 100 per cent so that there is not very much waste of water. The water consumption per capita is moderate, being approximately 84 gallons per day, which should perhaps be considered a little high since some of the largest manufacturing industries have their own water supply.

Unfortunately, too, the war prevented the making of improvements for meeting the increased demands, and at the end of the war, like many other water works, Cedar Rapids was a long way behind in its program of expansion.

The supply consists of two sources, the Cedar River, and two 10 inch artesian wells, 1450 feet deep. The wells are pumped by electrically driven Hill-Tripp axial impeller pumps, one of which lifts the water about 75 feet to the surface and the the other has a centrifugal pump on same shaft which pumps the well water directly into the pipe system. The Cedar River water is now purified by short sedimentation and sand filtration. A part of the filters are of the old Jewell wooden tub type, installed 26 years ago. There are also

[1] Presented before the Iowa Section meeting, November 3, 1922.

[2] Superintendent, Water Works, Cedar Rapids, Iowa.

two units of concrete construction 10 years old. The wells have a capacity of about two million gallons, and the filters about seven million gallons per day. Until this season no sedimentation space was provided for preparing the water for filtration except a small compartment in the bottom of the tub filters. River water was, therefore, supplied directly to the filters without any preparation except the addition of alum solution into the suction pipe of the pump. This solution was somewhat mixed with the river water by going through the pumps, and coagulation had started when water reached the filter beds. The absence of sedimentation made the operation of the filters extremely difficult, especially during periods of high turbidity in the river water. The large amount of solid matter which collected on the surface of the filters was hard to remove, and washing of filters sometimes resulted in rolling the surface sediment into balls. Our plant gained a reputation of forming mud balls in the sand beds. The direct system of pumping together with limited clear well capacity, coupled with the above condition of the filter plant, created a problem in providing an adequate supply of water during the peak demands.

The consumption of water has exceeded six million gallons per day and, under direct pumping, periodic demands during the evening sprinkling hours during hot weather has been as high as a rate of eleven million gallons per day. In short, the problem confronting our water works when the speaker became connected with it two years ago, was to provide adequate fire protection and a peak demand as high as a rate of eleven million gallons per day with a supply of less than this amount, and subject to considerable decrease by possibility of breakdowns of well pumps and difficult operation of filter plant because of lack of sedimentation facilities.

Since the location of the present plant is such that the nesessary space for expansion, and especially for sedimentation basins, is not available, it was deemed impractical to make any more additions to the present purification plant, or any improvements except those absolutely necessary, and to bring the present equipment to as high efficiency as possible with as little investment as possible, because sooner or later a new location for a purification plant would have to be provided, or a different supply secured. It is possible to get a good flow of artesian water in Cedar Rapids, and the possibility of meeting the increased demand with additional wells has been under consideration. The situation called for the immediate adoption of

some improvement program and a study of the local conditions for reaching conclusions as to the best source of future supply, whether it should be artesian wells or Cedar River, or both. Burns & McDonnell, consulting engineers, of Kansas City were called in to give their recommendation on these questions. A program of improvement was adopted about a year ago which is based on their recommendations, with some changes in details.

The improvements decided upon were divided into two parts: First, making a change from direct pumping to a gravity supply, by constructing a reservoir with a storage capacity of more than the present maximum days demand, also to lay a system of feeder mains to provide satisfactory pressure in all parts of the city. The second part of the program will consist of a new or increased source of supply, but whether this will be Cedar River or artesian water, or both, has not yet been fully decided. The first part, practically completed this year, consists briefly of the following work: The construction of a seven and one-half million gallon reservoir in Beaver Park at an elevation approximately 170 feet above, and two and one-half miles distant from the business section of the city, and a system of feeder mains consisting of a main pipe line, 24 inches in diameter, from the business section direct to the reservoir, and about four miles of secondary feeder laterals.

For this purpose a campaign for a bond issue of $450,000 was started early this year and voted on at the spring election, with the votes approximately two to one in favor of the proposition. Only $400,000 of these bonds will be issued, as this amount will be sufficient to finance the improvement. A contract for the reservoir was let May 26 for approximately $100,000, and the concrete work is now practically completed. The main feeder pipes will be completed in about two weeks and during the first of December we except to put this part of the improvement in service, and thus change from direct pumping to a gravity supply.

This part of the work will give the advantage of a comparatively large storage for fire protection, and of permitting the operation of our wells and purification plant at a uniform rate throughout the twenty-four hours of the day and thereby meet the demands on our system for a few years. In the meantime it is our purpose to prepare for the second development in the improvement plan, that of providing the best possible supply for the future. If river water will be continued, it is the intention to build an up-to-date purification plant and pumping station in a new location.

The adoption of a reservoir gravity system in place of direct pumping precludes the continuation of increased pressures in the system during fires. It is our opinion that, under our conditions of operation, particularly with limited supply and the undesirability of increasing it in piece-meal fashion, it was the proper solution. The variations in demand at different hours of a day in this city have been as high as 400 per cent. Such high variation does not occur often, but it must be met when it does occur. Adequate storage in a gravity supply, therefore, makes it possible for a given supply and pumping equipment to give at least double the service that can be given without such storage, besides giving the added protection of a large amount of water directly available without pumping in case of large fires. These advantages are more desirable than increased pressures under limited capacities from direct pumping, especially in large cities where fire pumpers may easily furnish the increased pressures during fires.

By this change the present supply and pumping equipment will be able to furnish an adequate quantity for a few years, and permit sufficient time for proper investigation and development of a permanent supply for the future. It will also be possible to get better results from the filter plant because it will not be necessary to run filters beyond proper rates for good results.

THE DRY FEED OF CHEMICALS[1]

By L. M. Booth[2]

The use of continuous dry feeders for chemicals in water purification is the result of the successful employment of dry feeding apparatus in the cement, grain, chemical and other industries. The problem before our designers has been to adapt well known and tested equipment to water purification uses.

In some of the larger water filtration plants, for example at St. Louis, where the volume of chemicals to be handled is greater than in most plants, the plan of adding weighed batches of dry chemicals was adopted with the inception of chemical treatment at St. Louis in 1904.

So far as the speaker is aware, credit for the initial development of continuous dry chemical feeders in water purification belongs to Allen Hazen and Robert Spurr Weston, who first used a screw type conveyor feeder in 1907, at Brisbane, Australia.

At this time there are about 400 dry feeders in water purification plants in the United States. This includes large industrial installations as well as filter plants purifying public supplies.

The various commercial feeders now on the market may be divided into the following four classes: Screw conveyor, ribbon conveyor, drum wheel, and table feeds. Most manufacturers arrange for the operation of feeders by means of electric or water motors. In some instances, power is taken from a line shaft. The amount of power required varies from approximately 0.1 to 0.5 horse power, depending upon the size and type of the feeder.

Most feeders are designed for pulverized or small lump material. Some feeders readily handle, without previous screening, cakes of lumpy hydrated lime, soda ash, sulphate of aluminum or sulphate of iron. The handling of large lump material (not ground) is a benefit only when pulverized chemicals are not available, as for example

[1] Presented before the North Carolina Section meeting, November 16, 1922.

[2] President, Booth Chemical Co., Elizabeth, N. J.

where sulphate of aluminum is made at the filtration plant and is merely crushed into large lumps before use. Since the chemical manufacturer's price of pulverized sulphate of aluminum is the same as that of the lump product, the feeding of lump material may be, in instances where the chemicals are purchased, a distinct disadvantage. The reason is that provision must be made for dissolving the lump chemical before it is introduced to the water to be purified.

While all manufacturers of dry feeders for water purification are in a position to supply solution making equipment, a number of them recommend that the feeders be installed so that the dry pulverized materials may be discharged from the feeder directly into the water to be treated. Of course, in many plants, where existing conditions prevent the direct application of the chemicals to the water, it is necessary to convey them from the feeder to the point of application by a stream of water. This, in some instances, is provided by the waste water from the water motor driving the feeder.

The ideal place for the installation of a dry feeder is in the chemical storehouse, if this is within a short distance of the filter plant. As previously noted, the water entering the plant should pass beneath the feeder on its way to the coagulating basin. If this arrangement is provided for, it is possible to install the chemical feeder so as to insure the minimum handling of chemicals. The practice of installing chemical feed apparatus right under the filter operator's nose, as has been determined to be desirable by experience with orifice boxes, need not be followed with dry feeders. These are reliable and the service is not subject to the interruption due to the accumulation of foreign matter in pipe lines, valves, etc., which is the usual experience where solutions are handled.

The prices of standard dry feeders vary from about $300 to $1200. In each case the figures named include the complete feeder, with supply hopper, electric motor, and solution equipment. The range of feed for any given machine is usually such that the maximum feed is ten times the minimum. This is from a few pounds per hour, in the case of the lower priced feeder, up to 1000 pounds per hour for the larger feeders.

Besides the advantage of low first cost, the dry feeder is more economical of space than solution tanks and orifice boxes.

For new plants, the use of dry feeders permits important savings in building construction. The second story, frequently the logical

location for chemical storage when solution tanks are used, is not needed.

All filter plant operators are familiar with the corrosion, stoppage and leakage of coagulant piping. This nuisance can be eliminated absolutely by installing the dry feeder so that the inflowing water receives the dry chemicals.

Besides the advantages of simplicity, low first cost, and ease of control, the dry feeder method is characterized by a certainty of operation not readily obtained by other means.

FINAL REPORT OF THE COMMITTEE ON SANITARY DRINKING FOUNTAINS[1]

The advent of sanitary drinking fountains was the direct result of laws prohibiting the common drinking cup. In 1910 there were few states or municipalities which prohibited the use of the common drinking cup. By 1920 many states recognized the necessity of prohibiting the use of the common cup and laws for its prohibition were enacted. Eight states passed such laws in 1917 and six more in 1910. Manufacturers of sanitary equipment recognized readily the lucrative field for specially designed drinking facilities, and during the period from 1910 to date about twenty large scale manufacturers and numerous small dealers were offering various types of sanitary drinking fountains to the trade. In the early period of the manufacture of such equipment little attention was given to the public health aspect of the apparatus placed upon the market. No special thought was given, at first, to the sanitary efficacy of the equipment, with the result that many types of fountains were put in service, the use of which were as potentially dangerous in the transmission of infectious diseases as was the common drinking cup. Numerous investigations carried on in the past few years have demonstrated clearly that the straight jet fountain, permitting the incoming water to pass through a cup or reservoir that is not drained, and other poorly designed apparatus, may result in the transmission of bacteria from one person to another. In the conclusions reached by the committee of the Iowa Section of this Association, in their report of October 23, 1919, definite recommendations are given for the type of fountain that will eliminate opportunity for contamination. These conclusions are endorsed by your committee and are given herewith, in full, as they cover all the essential features of design of operation required in apparatus of this kind.

[1] This report has been prepared under the direction of Council. The personnel of the Committee is as follows: S. T. Powell, Chairman, Baltimore, Md.; John H. Dunlap, New York; J. H. Dunwoody, Erie, Pa.; Ralph Hilscher, Berkeley, Calif.; and W. M. Mitchell, Gross Ile, Mich.

Conclusions. 1. All types of drinking fountains with vertical jets are to be condemned.

2. Most types of drinking fountains with slanting jets are to be condemned.

3. To be sanitary, drinking fountains should conform to the following specifications:

a. The jets shall be slanting.

b. The orifices of the jets shall be protected in such a manner that they cannot be touched by fingers or lips, or be contaminated by droppings from the mouth, or by splashings from basins beneath the orifices.

c. The guards of the orifices shall be so made that infectious material from the mouth cannot be deposited upon them.

d. All fountains shall be so designed that their proper use is self-evident.

Your Committee has devoted its efforts primarily to reviewing the present status of laws which have been enacted to control the installation of equipment of this type. It has considered also the need for future legislation and control to prevent the use of insanitary drinking fountains. At the close of 1921, there were laws or sanitary regulations in many states specifying the use of sanitary drinking fountains. Few states, however, have adopted specifications for the design of fountains which are efficient or satisfactory. There is a need still for bringing before the public and many of the health authorities the potential danger that exists in the use of sanitary drinking fountains of many types now offered to the trade.

Section 61 of the Railway Sanitary Code of the United States Public Health Service specifies the kind of fountain permissible. These specifications are as follows:

Sec. 61. Drinking Fountains.—If drinking fountains of the bubbling type are provided in any railway station, they shall be so made that the drinking is from a free jet projected at an angle to the vertical and not from a jet that is projected vertically or that flows through a filled cup or bowl.

This portion of the code is a decided step forward in attempting to eliminate the installation in railway stations of fountains of dangerous design. The specifications, in our opinion, are not sufficiently complete, however, in that no mention is made of the guards that should be used, nor is any provision made for protecting the jet from the mouth or fingers of the users.

A review of the trade catalogues of recent date has shown that there is still a great variety of sanitary drinking fountains offered to the public, a large majority of which are of the insanitary type. Many of these apparatuses in no way meet the requirements set forth by

the Committee of the Iowa Section, or of Section 61 of the Railway Code. This condition may not be as discouraging as it appears, however, due to the fact that many of the manufacturers do not revise their catalogues every year. We are of the opinion, however, that there are still a large number of poorly designed drinking fountains manufactured and sold. This condition will exist until the manufacturers realize that only sanitary fountains of good design are in demand.

During the past year a large number of sanitary fountain installations have been inspected. Less than 10 per cent of the number of fountains inspected were of the design that prevent infection being transmitted directly from one person to another, and only 5 per cent might pass Section 61 of the Railway Code. Not one of these installations could meet the requirements specified by the Iowa Section. This appears to be a serious indictment against the enforcement of health regulations, since in every instance where this condition existed there were laws to prohibit just this situation. As a result of these studies the following conclusions and recommendations are given:

CONCLUSIONS

1. Infections may be transmitted from one person to another from sanitary drinking fountains of the bubbling type with undraining reservoir, or fountains that permit the mouth or hands to come in contact with the surface of the jet.

2. Many manufacturers of fountains are not familiar with the sanitary requirements to be met by such apparatus.

3. Laws on the statute books regarding drinking fountains of many states are not enforced.

RECOMMENDATIONS

1. The Association should adopt the specifications for sanitary drinking fountains recommended by the Iowa Section, October 23, 1919.

2. All sanitary drinking fountains installed in public places should be of the standard design as set forth herein, or of such a design as to fulfill the sanitary requirements made necessary by the improved type.

3. Legislative regulations in all states, where these are not now in force, should specify the type of sanitary fountain to be permitted.

4. Copies of this report should be sent to technical papers, having a circulation among manufacturers of drinking fountains, requesting that the report be published in full.

5. Stricter supervision by health authorities of the type of drinking fountains installed in new buildings should be brought about.

DISCUSSION

ON VALUATION[1]

That the art of valuing public ulitity properties for rate making purposes has not been developed to a stage that will permit of the deduction of principles sufficiently definite to constitute an exact science, the three decisions in the Southwestern Bell, the Bluefield Water, and Atlanta Gas cases handed down last year by the Supreme Court of the United States, clearly and unmistakably demonstrate. And who is there that would have valuation made such a positive rule that all the elements which give to each case its individuality would be impossible of consideration, and that Courts and Commissions would be hampered in the application of that calm and deliberate judgment which is essential to the determination of that value which is just and reasonable to the public, to the utilities, and to the security holders alike?

From the Southwestern Bell and Bluefield Water cases in particular, it seems certain that actual consideration of, and substantial weight to, the present greatly increased cost of labor and materials must be given; but that reproduction cost is not *the* measure of value is equally certain and that the terms "reproduction cost" and "present fair value" are not synonymous must be admitted by even the most partisan observer. It is interesting to note that original cost is still a measure of value and may, when it represents property installed at well distributed points over the price curve (as with the Bluefield water properties), become the controlling measure. Accrued depreciation still seems to be a factor that must be reckoned with in considering both the cost to reproduce and the original cost.

The three decisions are undoubtedly a decided contribution to the subject of valuation, but in the final analysis, stripped of their legal phraseology, placed side by side, and viewed through their majority opinions (which become the law), illumined by the forceful language of the minority, what more do they say than that the Court still adheres to the principle enunciated twenty-five years ago

[1] JOURNAL, January, 1924, page 1.

in *Smyth versus Ames?* One Commission was reversed because it had failed to take into consideration the increased cost of labor and materials; another was reversed because the rates set by it did not allow a fair return on even the minimum value which might be placed on the property; and a third was upheld after it had given consideration to the increased cost of reproduction *less depreciation* and to all the other elements of value and had finally adopted as rate base a figure which very nearly represented the original cost.

The Southwestern Bell case touches a point which, to my mind, is most significant. In this connection the Court says, "An honest and intelligent forecast of probable future values, made upon a view of all the relevant circumstances, is essential." Evidently the Court had in mind the establishment of the very "stable" rate base for which Mr. Justice Brandeis contended when he declared, in his minority opinion, "The adoption of the amount prudently invested as the rate base and the amount of the capital charge as the measure of the rate of return would give definiteness to these two factors involved in rate controversies which are now shifting and treacherous, and which render the proceedings peculiarly burdensome and largely futile. Such measures offer a basis for decision which is certain and stable. The rate base would be ascertained as a fact, not determined as a matter of opionion. . . . . It would not be distorted by the fickle and varying judgments of appraisers, commissions, or courts." He probably had in mind some of the "expert" testimony which is to be expected in every rate case and from which Commissions and Courts are supposed to decide whether a property can grow up over night ready to perform all the functions of the existing plant and if so whether the effect of its hasty erection, coupled with its long drawn out appraisal, should cause it to be burdened with an "overhead" cost several times the cost of its physical elements, or whether on the other hand the property has been rapidly deteriorating from the time of its very inception in the promoter's mind, until today its value has been reduced to an infinitesimal part of the original. If there is one thing for which Mr. Justice Brandeis did argue, both in his two minority opinions and in his majority opinion, it was that the findings of Commissions as to values are to be accorded great weight, but that this very fact makes it incumbent upon the value-determining body to keep its feet on the ground and deal fairly with utilities and public alike in order to attract, by a conservative degree of certainty of return, that capital the flow of which into its properties is the very life blood of public utilities.

A reading of these three decisions leads one to the conclusion that too much emphasis is being placed on the valuation process and results and that insufficient weight is being given to the many other factors involved. The rate of return should be more strongly stressed. When Commissions have gotten to the point of granting increases for skillful and economical operation and permit utilities to share in the fruits of good management, and on the other hand when public service companies content themselves with a reasonable rate of return on something less than the highest valuation which they can possibly claim, much of the agitation over valuation will cease and the rate making process will become more of a rational adjustment of the economic features presented in each particular case. Certainly a low rate of return and a low valuation is no fairer than a high rate of return and a high valuation unless the interests of the public and the utility alike are served by this combination.

The fact that the Supreme Court set its stamp of approval on the 4½ per cent gross earnings charge levied on its subsidiaries by the American Telephone and Telegraph Company is, to my mind, the outstanding feature of the Southwestern Bell case. The fact that the valuation of franchises to do business and the inclusion of so-called losses from operations during recent years were excluded from the Atlanta gas case are of deeper moment than the question of valuation. That a 6 per cent return is too small and that, "A return of 7.25 per cent—in addition to this tax exemption—can not be deemed confiscatory" goes far toward clarifying one important element ever present in rate cases. Likewise the treatment of the federal corporate income tax as an operating charge will dispell many doubts on this question.

H. Carl Wolf.[2]

[2] Chief Engineer, Public Service Commission, State of Maryland.

SOCIETY AFFAIRS

EXECUTIVE COMMITTEE MEETING

The Executive Committee of the Association held a special meeting in New York City on January 18, 1924 at the call of President George W. Fuller. The following resolutions and motions were passed.

WHEREAS, For many years John M. Diven, Past-President of the American Water Works Association, has served as its Secretary, with unflagging interest in its welfare and at a sacrifice of time and effort rarely made by the officers of societies of this character; and

WHEREAS, In taking charge of the water works of Troy, N. Y., Mr. Diven has felt it desirable to be relieved of the detail work which the Constitution imposes upon the Secretary;

Therefore Be It Resolved, by the Executive Committee of the Association, assembled at a Special Meeting in New York on January 18, 1924, that the resignation of Mr. Diven as Secretary be accepted with the appreciation by the Executive Committee of his past services as the Secretary, as expressed herein, and that the President be and hereby is requested to present the name of Mr. Diven for Honorary Membership at the next annual convention of the Association.

And Be It Further Resolved that the Executive Committee recommend that the position of Secretary Emeritus be established by amendment of the Constitution and that, pending action on the establishment of this position, the Executive Committee employ Mr. John M. Diven at the salary of Fifteen Hundred ($1500) Dollars per annum with the office title of Secretary Emeritus, his duties to be developing the interests of superintendents in the work of the Association, assisting in the increase in membership of the Association and advertisers in the JOURNAL, assisting in the preparation of the program for the convention with special reference to the superintendents, and attending the convention and assisting in the conduct thereof.

It is regularly moved and carried that a Committee consisting of the President, Mr. Fuller, the incoming President, Mr. Jordan and Messrs. Bartow, Cramer, Batchelder, Andrews and Brush be appointed to make recommendations as to the filling of the Secretary's office, location of the headquarters of the Association and other questions pertinent thereto.

It is regularly moved and carried that the Membership of the Association be advised through publication in the March JOURNAL of the resignation of Mr. John M. Diven as Secretary, and that Mr. W. M. Niesley, the present office assistant, will temporarily carry on the duties of the Secretary's office under the direction of the President pending the selection of a Secretary.

Special Notice

The Secretary's office has been transferred to Rooms 1012-13, 170 Broadway, New York.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Revolving Screens for Low-lift Pumping Station, Detroit, Filters. T. A. LEISEN. Eng. News-Record, **91:** 14, 1923. Seven sets of screens, each operated by 5 H.P. motor and at speed of 10 ft. per min., are installed in Detroit water purification plant, at point before water reaches pumps. Each screen is made up of 38 panels 24″ × 72″. Function of screens is to intercept all floating or slush ice coming through tunnel and incidentally, to prevent passage of fish and floating debris. Opening in screens is ¼″ square.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Coal Storage for Year's Supply for Detroit Water-Works. ANON. Eng. News-Record, **91:**10–11, 1923. Duplicate coal handling equipment, boiler houses, and coal sheds, with storage capacity of 25,000 tons, give continuity of service. Coal is brought in by barges, dumped into hopper with reciprocating feeder, and crushed by 30″ double-roll crusher fitted with replaceable steel teeth. Crushed coal is conveyed to storage house by 24″ belt conveyor. —*Frank Bachmann.*

Successful Means of Removing Hard Spots from Filter Beds. W. C. WILLS. Eng. News-Record, **91:** 232–3, 1923. Underdrains consisted of 1¾ inch C.I. laterals on 6-inch centers, drilled every 6 inches with 2 holes, ¼ inch diameter. Inspection showed that the gravel had cemented above laterals, stopping flow of wash water. Tailings in varying sizes, from 2 x 4 x ¾ to 5 x 6 x 2 inches, substituted for gravel over laterals, removed difficulties.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Waltham, Mass., Reservoir Waterproofed by a New Lining. M. W. FISHER. Eng. News-Record, **91:** 185, 1923. Disintegration of reinforced concrete, due to seepage and frost action, made more waterproofing necessary. Waterproofing consisted of mop coat of Texaco No. 56 waterproofing asphalt, applied hot to inside wall. Waterproofing felt was then applied with another coat of Texaco No. 56. This operation was repeated 5 times, outside layer, however, being a 6 oz. saturated duck fabric. Following this, 4 inch brick facing was constructed from floor to top of wall.—*Frank Bachmann.*

How Oklahoma City Water-Works Dam Withstood Floods. A. S. Holway. Eng. News-Record, 91: 292–4, 1923. Previous records were broken by June floods. Practically all bridges on North Canadian River were washed out. Flood threatened waterworks storage reservoir of Oklahoma City as twice the capacity of spillway passed over dam. By using sand bags by thousands, dam was saved.—*Frank Bachmann.*

Aluminum Hydroxide Solution. Joseph W. Coxe, Jr. Chem. and Met. Eng., 29: 279, August 13, 1923. New coagulating agent, suitable for water purification, described. Addition of concentrated solution of soda ash to concentrated solution of aluminum sulfate, in proportion of one part of soda ash to 4 parts of alum, forms no precipitate. Diluting causes coagulation. No alkalinity is required in water to be coagulated. Free CO_2 is liberated in the concentrated solution; most of it passes off as gas. Author claims that amount of aluminum sulfate necessary for clarification is not increased by this treatment.—*John R. Baylis.*

Wrestling with Water Waste in Chicago—Only 10 Per Cent Metered. L. R. Howson. Fire & Water Eng., 73: 727, April, 25 1923. Chicago water works at present time has 7 cribs: 60 miles of tunnels, from 5 to 14 ft. in diameter, with nominal capacity of over 1,400 million gals. per day. There are 10 major pump stations, with normal capacity of 1,150 million gals. per day, and average daily pumpage of nearly 800 million gals. It serves population of nearly 3 million poeple, in area of approximately 200 sq. miles, through c.-i. mains, from 4 to 48-in. diameter with aggregate length of nearly 3000 miles. It supplies approximately 325,000 premises, of which less than 10 per cent are metered; remainder being on frontage assessment basis. In 1921, the metered 9½ per cent of the services used 25 per cent of water pumped, and paid, at average rate of 6¼ cents per 1000 gals., for all water used. Remainder of supply, unmetered, yielded revenue of but 1.6 cents per 1000 gals., or, materially less than cost of supplying it. Average pressure at present is approximately 20 lbs.; nearly three-quarters of city is suffering from insufficient pressure for fixtures on third floor to be used at all times. This is due to friction loss resulting from passage of excessive amount of water through mains. It is believed that 125 gals. per capita per day represents use and unavoidable loss of water. Gross pumpage in 1921 averaged 267 gals. per capita per day, leaving preventable waste at 151 gals. per capita per day, or approximately 56 per cent of total pumpage. Amount of preventable waste, approximately 425 million gals. at present time, is more than combined gross pumpage of Cleveland, Milwaukee, Cincinnati, Newark, New Orleans, Providence, Atlanta, Boston, and Columbus, serving over 3 million people. If present waste continues, daily consumption in 1950 will be approximately 2,000,000,000 gals. If meters are placed on all new services, and careful leakage survey inaugurated, it is believed that daily consumption can be reduced not to exceed approximately 1,400,000,000 gals. in 1950; if meters are placed on all services in next 10 years it is believed consumption can be reduced to 600,000,000 gals. per day in 1950. It is estimated that expenditure of 88 million dollars on plant additions in next 30 years can be saved, if universal metering put into effect within next

10 years; savings in operation are estimated at 145 million dollars. Nine examples are given to show what metering has accomplished in other cities. Article is well illustrated by diagrams. (*Cf.* this J., 10: 1135).—*Geo. C. Bunker.*

Gravel Versus Rock as a Source of Well Water. JOHN W. TOYNE. Fire & Water Eng., 73: 827, May 9, 1923. Summary of studies of water supply in connection with new pump station for South Bend, Ind., having ultimate capacity of 25,000,000 gallons per day; and short notes concerning wells drilled at other places. Care must be taken not to select a strainer with combination of metals that will set up electro-chemical action and render well useless within a few years. After strainer set, finer particles in strata must be worked through it, and removed from well; air is most effective agent for this. Author's experience and observations lead him to question desirability of water supply in rock, if one is available in suitable gravel strata under favorable topographic conditions.—*Geo. C. Bunker.*

Water Purification Problems—How They Should be Handled. F. A. DALLYN AND A. V. DE LAPORTE. Fire & Water Eng., 73: 819, May 9, 1923. Sources of supply for municipal water works in Ontario are, with few exceptions, "clear waters." Problems of filtration are the removal, respectively, of (1) bacteria derived from sewage contamination; (2) occasional turbidity; (3) color and organic matter; and, for a few supplies, (4) considerable quantities of turbidity. Economically, problem is removal of color in northern parts of Province; and removal of iron and occasional turbidity in Trent and Rideau Valleys. Where water receives 2½ grains per gal. of alum, cost of alum alone will be from two to three times actual amortisation burden of the plant. Trend of practice is toward decreasing bacterial efficiencies in rapid sand filtration, and supplementing filtration by chlorination. Fortunately this trend of practice, is not, under present conditions, attended by serious health hazards, because last 10 years have witnessed immense declines in incidence of typhoid fever, so that water supplies do not to-day represent potential danger they did in last decade. In Province of Ontario much emphasis placed upon location of points of intake for supply. Very few plants, furnishing domestic water supplies, have intakes subject to such gross pollution, as prevails in many American cities. Density of population in U. S. calls for size of plant rather larger than is the rule in Ontario. Use of sedimentation basins with minimum of two hours storage is very advantageous for all colored waters and for iron-bearing waters. Pressure type of filter, without coagulation basins, is adequate, provided theoretical quantities of alum applied, to take care of occasional turbidity; but difficulty of controlling alum dosage requisite for rapid precipitation is so great, that this type is not advocated for waters which may be classed as resistant to treatment. Experimental evidence indicates that for soft, colored, waters optimum condition for coagulation is when H-ion concentration of water has been adjusted through use of alum to pH value of 5.5; for harder waters, and for Great Lake Basin, optimum condition exists when pH value adjusted to neighborhood of 6.5 (*cf.* this J., 10: 1138).—*Geo. C. Bunker.*

Analysis and Physical-Chemical Examination of the Thermal Carbonated-Sulfuretted-Borated Water of Saturnia. R. Nasini and C. Porlezza. Gazz. Chim. Ital., 52: 1, 115–24, 1922. From Chem. Abst., 16: 1834, June 10, 1922. Report of detailed examination of water of this old spring which is a bright colloidal solution of sulfur. Temperature is 37.5°C.—*R. E. Thompson.*

The Manufacture of Fused Cement. E. Candlot. Chimie et Industrie, 7: 456–7, 1922. From Chem. Abst., 16: 1845, June 10, 1922. Fused cement consists essentially of calcium aluminates. Of the four known compounds ($5Al_2O_3.CaO$; $Al_2O_3.CaO$; $3Al_2O_3.5CaO$; $Al_2O_3 . 3CaO$) the first three yield, on clinkering, hydraulic products which set slowly and harden rapidly. Most valuable characteristics are, resistance to sulfate-bearing waters; slow setting; and rapid hardening (strength at end of three days is equal to that of good grade artificial cement after 28 days).—*R. E. Thompson.*

Influence of Drying on the Resistance of Cement Blocks. F. Anstett. Rev. Mat. Constr. Trav. Pub., 148: 1–2, 1922. From Chem. Abst., 16: 1846, June 10, 1922. Cement briquettes were completely immersed in water for different periods and tensile strength tests made on some immediately after removal, and on others, at periods of 7, 20, and 26 hours after removal. In all cases strength of body was greatest immediately after removal, and decreased markedly as period from time of removal increased.—*R. E. Thompson.*

Electrical Charges of Colloidal Particles and Anomalous Osmosis. Jacques Loeb. Jour. Gen. Physiol., 4: 463–86, 1922. From Chem. Abst., 16: 1786, June 10, 1922. Interesting discussion of transport of water across collodion-gelatin membranes separating salt solutions and water. Cf. C. A., 14: 1246, 2285, 2286, 2573; 15: 2455; 16: 726, 1597.—*R. E. Thompson.*

Determination of Organic Matter in Water. Reinaldo Vanossi. Anales. Soc. Quim. Argentina, 9: 276–91, 1921. From Chem. Abst., 16: 1825, June 10, 1922. Amount of potassium permanganate consumed in presence of sulfuric acid, potassium hydroxide, and sodium bicarbonate, by samples of water containing various amounts of organic wastes was determined. Results were so widely divergent that no definite conclusions could be drawn.—*R. E. Thompson.*

The Removal of Mineral Plant Food by Natural Drainage Waters. J. S. McHargue and A. M. Peter. Kentucky Agr. Expt. Sta. Research Bull., 237, 1921. From Chem. Abst., 16: 1827, June 10, 1922. Analyses are given of samples of water from streams and springs in Ky. and from a few places in other states, including data for some of largest rivers in United States. Greatest amount of nitrate nitrogen found in water containing large amounts of phosphorus, indicating parallelism between soluble phosphorus and nitrate nitrogen. High phosphorus content of soils accelerates activity of nitrifying organisms.—*R. E. Thompson.*

Results Achieved by the Corrosion Committee, British Institute of Metals. E. E. Theim. Chem. Met. Eng., **26**: 301–6, 1922. From Chem. Abst., **16**: 1735, June 10, 1922. Failure of brass condenser tubes in marine service is caused by lodgment of solids, harmless in themselves, which trap corrosive substances formed during inevitable process of slow general thinning. Mechanism of this form of corrosion explained.—*R. E. Thompson.*

Influence of Physical and Chemical Treatments on the Adsorptive Capacity of Fullers Earth. G. H. A. Clowes and G. B. Walden. Proc. Am. Soc. Biol. Chem.; Jour. Bio.-Chem., **46**: 18–9, 1921. From Chem. Abst., **16**: 1784, 1922. Adsorptive capactiy for alkaloids appears to be direct function of amount of iron and aluminum contained in Lloyd's reagent and to be adversely affected by silica. Water loss on evaporation has similar effect.—*R. E. Thompson.*

How Should the Watershed be Protected from Pollution: Geo. C. Hodges. Fire & Water Eng., **73**: 681, April 18, 1923. General remarks about improving sanitary conditions on watersheds of the supply of Utica, N. Y. The Kentucky sanitary privy was adopted and has given perfect satisfaction.—*Geo. C. Bunker.*

Political Versus Non-Political Management. R. E. McDonnell. Fire & Water Eng., **73**: 719, April 25, 1923. Protest against management of municipal water works by political boards.—*Geo. C. Bunker.*

Composition of Foams. J. Chatelan. J. Chim. Phys., **20**: 123–131, 1923: Chem. & Ind., **42**: 739 A, August 10, 1923. Gibbs' law connecting surface concentration of a dissolved substance with effect of substance on surface tension of solvent, cannot be confirmed by study of composition of foam produced with aid of saponin, or other colloids. Colloid present in foam takes with it quantities of electrolytes far in excess of amount required by Gibbs' law. In studying foams produced by discharge of effluents into streams, methods based on laws governing adsorption must be used; the important factors being nature, quantity, and dimensions of micelles, acting as carriers of electrolytes, that accumulate in foam. It is necessary also to take into account evaporation, which may further increase concentration of foam. (J. F. S.)—*A. M. Buswell.*

28th Annual Report, Superior Board of Health, Quebec. (1921–2). 412 pp. Improvement effected in river water supplies in a score of municipalities has reduced typhoid death rate in Province from 26.0 to 18.0 per 100,000. This might be lowered to 10, if raw river waters, supplying population of 200,000, were improved. Further research was carried out along two particular lines of investigation: (1) Detection and differentiation of organisms of colon-aerogenes group; (2) Application of H-ion concentration to purification plant control. These studies are still in progress.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Typhoid Fever in New York City. Weekly Bulletin, N. Y. City Dept. of Health, 12: 154–5, 1923. During first quarter of 1923, 115 cases reported, increase of 67 over corresponding quarter, 1922. Part of increase due to outbreak in Borough of Queens. Probable mode of infection, as ascertained in 35 per cent of cases: 11, contact with active cases; 9, acquired out-of-town; and 20, by ice cream, apparently contaminated by carrier.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

How Sanitation Aids Public Health. Richard P. Walsh. Monthly Bulletin, N. Y. City Dept. of Health, 13: 31–8, 1923. Review of activities of sanitarian, and of progress in fields of air conditioning, sanitary plumbing, sewage disposal, industrial hygiene, ventilation, refuse disposal, rodent and vermin extermination, water purification, etc.—*R. E. Thompson.* (*Courtesy. Chem. Abst.*)

How Sanitation Aids Public Health. Alonzo Blauvelt. Monthly Bulletin, N. Y. City Dept. of Health, 13: 25–30, 1923. General discussion. Methods employed by New York City Dept. of Health in enforcing regulations governing sewage and garbage disposal, water supply, swimming pools, bathing establishments, etc., are outlined.—*R. E. Thompson.* (*Courtesy Chem. Absts.*)

Standby Units for Pumping with Comparison of Operating Costs. E. M. Proctor. Contract Record, 37: 467–9, 1923. While Diesel and semi-Diesel equipment are most economical as regards operating costs, a gasolene-engine driven unit could be operated for 30 days before combined operating and capital costs would equal that of steam-, or Diesel-, engine driven.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Safe Water Supplies for Rural Saskatchewan. R. H. Murray. Sanitation Bulletin 2, 1923, Dept. of Public Health, Saskatchewan, Canada. 28 pp. Methods of constructing, protecting from pollution, disinfecting, and selecting sites for wells described. Survey of Province has indicated that commonest cause of well pollution is lack of care in selecting suitable site. The average well water in Province contains approximately 100 grains per gallon of mineral salts, with $CaSO_4$ predominating, and remainder consisting of $MgSO_4$, Na_4SO_4, $CaCO_3$, Na_2CO_3, and NaCl in amounts decreasing in order given. Na_2SO_4 is sometimes present to extent of 4–5000 grains per gallon. All surface water supplies of Province are dangerous. Where ice is cut in winter for use as water supply during year, there should always be at least 2 feet of water under ice when cut, and surface of ice should be scraped free of snow, soft ice, and foreign matter, before storing. As added precaution, water thereform, should be treated with chloride of lime, or boiled. In some sections, rain water is only source of supply. Plant consisting of raw water tank, sand filter, and filtered water storage tank, based on annual rainfall of 12 inches on roof area of 3000 sq. ft., is described and illustrated.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Work of the Bureau of Laboratories During 1922. Wm. H. Park. Monthly Bulletin, N. Y. City Dept. of Health, 13: 73–88, 1923. Work of Bureau reviewed. A.P.H.A. standard methods used for all routine tests on water and milk. Drinking waters containing B. coli in quantities less than 10 cc., or with total bacterial count much in excess of 100 per cc., are listed as suspicious or polluted; but repeated tests and careful consideration of local conditions necessary, in order to judge quality of a source of supply. Standards for bathing pools using well, spring, or city water, permit presence of not more than 10 B. coli per cc. If river or harbor water used, it must not contain more than 30 B. coli per cc. Method of examination of shellfish consists of 5 parallel tests of pooled liquor of 5, or more, oysters. Liquor must contain less than 50 B. coli per cc. Operation of oyster purification plant at Inwood, Long Island, has resulted in considerable reduction in B. coli present in oyster liquor.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Effect of Composition of Brass on Corrosion. Philip Davidson. Chem. Met. Eng., 26: 773, 1922. From Chem. Abst., 16: 1927, June 20, 1922.—*R. E. Thompson.*

Electrolytic Concentration Cells as Accelerators of Corrosion. P. D. Merica. Chem. Met. Eng., 26: 773, 1922. From Chem. Abst., 16: 1927, June 20, 1922. —*R. E. Thompson.*

Causes of Corrosion in Brass. A. S. Cushman. Chem. Met. Eng., 26: 773, 1922. From Chem. Abst., 16: 1927–8, June 20, 1922.—*R. E. Thompson.*

The Treatment of Industrial Waste Waters. André Beltzer. Industrie chimique, 9: 95–100, 1922. From Chem. Abst., 16: 2000, June 20, 1923. General description of treatment of industrial waste waters, particularly those from sulfite and paper mills.—*R. E. Thompson.*

Hysteresis Phenomena and So-Called Mechanical Coagulation of Sols with Rod-Shaped Ultramicrons. G. Wiegner, J. Magasanik and H. Gessner. Kolloid-Z., 30: 145–65, 1922. From Chem. Abst., 16: 1892, June 20, 1922. Degree of dispersion was determined by ultrafiltration, by ultramicroscope, and by colorimetric measurements, and was found to change in course of time. The more concentrated the sol the more rapid was growth of particles. "Mechanical" coagulation was produced by filter paper, kaolin, carbon, wood fiber, silk threads, silicic acid gel and gelatin.—*R. E. Thompson.*

The Determination of Bromide in Brines and Mineral Waters. C. C. Meloche and H. H. Willard. J. Ind. Eng. Chem., 14: 422–5, 1922. From Chem-Abst., 16: 1919, June 20, 1922. Bromine, obtained by oxidation of bromide, is absorbed in sodium hydroxide solution, and the sodium bromate is reduced to bromide by hydrazine sulfate. After precipitation as silver bromide, weighed bromide is converted into silver chloride by ignition in chlorine; from weight of silver chloride, correction is made for small quantity of chlorine liberated with bromine by original oxidation.—*R. E. Thompson.*

Methods of Purifying Public Water Supplies. Norman J. Howard. Canadian Engineer, 44, 231–6, Feb. 13, 1923. Excellent review and discussion of modern methods of water purification. Slow sand, mechanical, pressure, Puech Chabal, and drifting sand systems of filtration are described, and relation of pH to filter efficiencies is discussed. Sterilization with chlorine, ozone, and ultra-violet rays; iron removal; copper sulfate treatment; and sedimentation and storage are also dealt with.—*R. E. Thompson.*

The Velocity of the Extension of Thin Layers of Oil on a Water Surface. Paul Woog. Compt. rend., 174: 162–5, 1922; cf. Langmuir, C. A., 11: 2849. From Chem. Abst., 16: 1891–2, June 20, 1922.—*R. E. Thompson.*

The Transition from Crystalloid to Colloid Properties within Homologous Series. E. J. Witzemann. J. Phys. Chem., 26: 201–16, 1922. From Chem. Abst., 16: 1892. June 20, 1922. Biocolloids are regarded as consisting of a concentrated solution suspended in a dilute one and it is pointed out that there is an unequal distribution of energy between the two phases. Two types of this energy differentiation are represented in electric charge on particles and in surface tension at interfaces.—*R. E. Thompson.*

Precipitation Equilibrium. Robert Griessbach. Z. Physik. Chem., 97: 22–94, 1921. From Chem. Abst., 16: 1900, June 20, 1922.—*R. E. Thompson.*

Modern Method of Water Purification. J. P. O'Callaghan. Shipping, Engineering and Machinery Exhibition, Olympia, Eng. Sept. 7, 1923. Water softening by lime-soda (hot and cold processes) and permutit methods is described. The introduction of a new material, "permutit B," has eliminated necessity of second softening apparatus for use during regeneration in case of latter method. Actual base exchange is somewhat less than ordinary permutit, but its action, during both softening and regenerating, is more rapid, permitting use of higher rates of flow and much shorter periods of regeneration—1 hour, as compared with 12 hours for permutit. The material is also of hardier physical character and therefore less susceptible to loss through wear.—*R. E. Thompson.*

The Relation between Flocculation, Adsorption, and the Charge on a Particle with Especial Regard to the Hydroxyl Ion. S. E. Mattson. Kolloidchem.-Beihefte, 14: 227–313, 1922. From Chem. Abst., 16: 2003–4, June 20, 1922. Results are given of extensive investigation on effect of ions on flocculation of colloidal substances found in soils, and on stability of aggregate formed. Hydroxides and oxides of iron and aluminum are negatively charged in aqueous suspension. Only by absorption of ions, originating in the formation (by preparation according to Graham) of some oxychloride ions, may they be positively charged.—*R. E. Thompson.*

Keeping Qualities of Solutions Containing Chlorine. K. A. Gandhi. Indian Med. Gaz., 57: 78–9, 1922; Pub. Health Eng. Absts., May 13, 1922. From Chem. Abst., 16: 2007, June 20, 1922.—*R. E. Thompson.*

Unbreakable Glass? ANON. Fachgenosse, **38**: 39–40, 1922. From Chem. Abst. **16**: 2015, June 20, 1922. New glass, Silex, is composed of 98 per cent quartz. Coefficient of expansion is so low that beakers and flasks with 1-mm. walls withstand abrupt changes of 400 deg. Glass is also resistant to severe shock tests, although not unbreakable. Color is smoky yellow.—*R. E. Thompson.*

Painting Cement Construction. HENRY A. GARDNER. Paint Mfrs. Assoc. of U. S., Circ. **147**: 180–5, 1922. From Chem. Abst., **16**: 2033. June 20, 1922. Suggested specification for treatment of cement surfaces: (1) New cement should be washed with zinc sulfate solution and allowed to dry at least 24 hours before applying paint; (2) For exterior surfaces, any high grade paint may be used; (3) For interior surfaces, lithopone paints give good results; (4) Cement floors may be hardened by washing with magnesium fluosilicate, sodium silicate, etc.; then painted with specially prepared cement floor paints. Cold water paints should never be used where humid conditions prevail.—*R. E. Thompson.*

The Aeration of Quiescent Columns of Distilled and of Salt Water. W. E. ADENEY, A. G. G. LEONARD, AND A. RICHARDSON. Phil. Mag. May, 1923, pp. 835–45; Water and Water Eng., **25**: 295, 265, July 20, 1923. Aeration is effected in still water by mixing of exposed layer with lower layers to depth of 10 feet; due to downward streaming. Mixing is accelerated by rise in temp. and is more rapid in salt, than in distilled, water.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Purification of Boiler Water. F. H. RHODES. Sibley Journal of Engineering, April, 1923, pp. 73–76; through Water and Water Eng. **25**: 295, 265, July 20, 1923. A general paper.—*Jack J. Hinman.* (*Courtesy Chem. Abst.*)

Common Drinking Cup. I. W. C. Pub. Health News, N. J., **8**: 8, 538, July, 1923. Note on case of typhoid developed in child who used common drinking cup immediately after thirsty golfer who was himself developing typhoid fever.—*Jack J. Hinman, Jr.*

Typhoid Fever at Rockaway, New Jersey. ANON., Public Health News, N. J., **8**: 7, 461 (1923). Epidemic of 41 cases and 4 deaths, due to cross connection from city supply to polluted private industrial supply which received drainage from septic tanks. Typhoid carrier of 4 years' standing was using toilet discharging into one of septic tanks. Flap of check valve between supplies was so encrusted that it could be moved only with a bar.—*Jack J. Hinman, Jr.*

Camp Sanitation Appliances. ANON. Public Health News, New Jersey, **8**: 7, 462, June, 1923. A general paper. Recommends boiling in preference to $Ca(OCl)_2$ treatment as more likely to be carried out properly, to safeguard water supply.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Hygienic Construction of Wells. Beninde. Volkswohlfahrt, 20: 48, Jan. 15, 1923; Bull. mens. office internat. d'hyg. publ., 15: 6, 857, June, 1923. Courses for constructors of wells were instituted in 1914 at Prussian Institute for Water Hygiene, and re-opened in 1922. Certificates are conferred.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Water Supply of the Province of Quebec. Ed. Imbeaux. La technique sanitaire et municipale, 17: 9, 224, Sept., 1922; Bull. mens. office internat. d'hyg. publ., 15: 6, 857, June, 1923. A general description.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Responsibility of Health Officers in Protecting the Public Water Supply. Jack J. Hinman, Jr. Journal of State Medical Society (Iowa); August, 1923. Work of State Water Laboratory assisting district health officers in control of public water supplies is described. Wells over 100 feet in depth must be examined every 6 months; less than 100 feet, every 3 months. Purification plants in Iowa State report at weekly intervals, giving amount of chlorin used and operating figures.—*N. J. Howard.*

Metropolitan Water Board. London, England. 17th Annual Report, 1923. Sir A. C. Houston. Report is most comprehensive in character and covers wide range of routine and research work. During year, some 12,994 samples were examined. Sources of London's water supply described; 80 per cent being derived from river sources and 20 per cent from deep wells. Water is distributed over total area of 537 square miles, supplying 7 million people: averaging about 36 imperial gallons per capita. River water is either stored or chlorinated prior to filtration. Part of well supply is chlorinated, due to slight pollution. Treatment includes super-chlorination with subsequent dechlorination using SO_2. By chlorinating raw river water instead of storing it, a water of better bacteriological quality was obtained, and actual saving in pumpage costs, etc., of $174,529 effected in period covering two years. Storage of water was found to have appreciable softening effect. When chlorine being used, taste troubles were occasionally experienced in New River supply; were overcome by permanganate treatment. No trouble experienced when treating Thames water, to which 0.5 p.p.m. of chlorine was applied. Experimental work of considerable interest on rapid sand filters is described, together with Sir A. C. Houston's views on relative merits of slow and rapid sand filtration. Report is classified under following headings:—resistance to filtration experiments; chlorination of river water; chlorination of well water; prefiltration waters; rapid filters; gulls and fish as sources of B. Coli contamination in water; bacteriophages; meteorological notes; growths in water on top of filters; comparisons between 1921–22 results and 1906–16 averages, description of diagrams and photographs; and general chemical and bacteriological tables. The work on bacteriophages (variously described as bacteriolysant, bacteriolytic enzyme, etc.) presents entirely new line in research. Bacteriophages are described as "being mysterious substances of recent discovery, which have the amazing power even in high dilutions of killing and dissolving certain bacteria." This special research work was undertaken in an endeavour to differ-

entiate B. coli of human origin and those derived from birds, fishes, and lower animals. Author suggests possibility of stored or filtered water containing bacteriophages which might have a lytic action on bacteria which might subsequently develop. "The results, although extremely interesting, as illustrating the behavior of bacteriophages towards intestinal bacteria, failed to establish the points of differentiation." Elaborate tables showing chemical and bacteriological quality of the various river and well supplies; diagrams; and large number of photographs of plankton growths are included. Report will be found of great value and interest to all concerned in purification of water.—*N. J. Howard.*

Reducing Ice Pressure with Compressed Air. Robt. G. Skirrett. Can. Eng., 45: 5, July, 1923. Compressed air system superior to steam jets for prevention of ice jams, and more economical to instal and operate. Ice exerts pressure in three ways all of which have to be considered. Water in freezing increases 8.4 per cent.—*N. J. Howard.*

Reservoir Site near Vancouver, B. C. Can. Eng., 45: July, 1923. Investigations have revealed hitherto unrecognized reservoir site in valley of Capilano river, five miles above waterworks intake of City of Vancouver. Dam 70 feet high would create reservoir about 3 miles long and 2000 to 3000 feet wide, having storage capacity of 6½ billion gallons.—*N. J. Howard.*

Water Storage and Distribution Control. E. Bruce Hall. Can. Eng., 45: 11, Sept. 1923. Illustrated article discusses mechanical contrivances and gives description of valves, sluices, weirs and dams employed on various important water supply projects in British Empire.—*N. J. Howard.*

Rich Mix Strengthens Concrete. From Concrete Data. Can. Eng., 45: 11, Sept., 1923. Controlling factor in strength of concrete is ratio between volumes of mix, water, and cement. Ordinarily concrete mixes contain 3 to 8 sacks cement per cubic yard. Each additional sack of cement per cubic yard will add 500 lbs per square inch to strength of concrete. Richer the mix, also, the more impermeable the concrete. Porous concrete may be injured by frost, allow leakage, or permit moisture to reach reinforcing steel and cause corrosion, with consequent spalling and damage. Impermeable concrete will be free from such troubles. Increased amount of cement does not alter cost of forms, nor labor of mixing or placing. It slightly reduces necessary quantity of aggregate. Extra cost is the additional cement, which is only fraction of total cost. Doubling quantity of cement increases cost only 5 to 15 per cent, while it doubles strength and durability. In structural concrete increased strength may permit use of higher stresses.—*N. J. Howard.*

Effect of Silt on Water Velocity. A. B. Buckley. Abstract of paper presented Inst. of Civil Eng. Can. Eng., 45: 14, Oct., 1923. Velocity of water varies with variations in silt content. Reduction of 14 per cent in velocity of Nile River, Egypt, was observed with increased silt content; difference in hydraulic radius would only account for 2 per cent. General formulae for

flow of water in open channels are discussed, it is shown that variations in velocity are such as to point to influence of new factor hitherto absent from hydraulic formulae. New formula, which includes a silt factor, is put forward for computing velocity of Nile River.—*N. J. Howard.*

Water Meters Increase Revenue. Anon. Can. Eng., 45: 15, Oct., 1923. Metering of water services in and around Montreal, Canada, producing satisfactory results. Metropolitan Commission will issue instructions that water services be metered in Pointe Aux Trembles, Laval, and Montreal East. In St. Laurent, previous deficiency in operation of water system, replaced by surplus of $7000 after metering.—*Norman J. Howard.*

Keeping our Water Fit to Drink. Dr. Frank Hale. Scientific American. November, 1923. Résumé of steps taken to control New York City water supply. Three laboratories maintained and microscopic examination carried out daily. During 1922, 4177 microscopic examinations made. Reservoirs with top and bottom draft examined at top and bottom. Generally speaking, microscopic examination serves to identify source of water. Contamination of well supply may be indicated by presence of microscopic organisms. Taste and odors may be caused by 22 species. Asterionella produces aromatic odor when present in 500 to 1000 standard units per 1 cc. With 1000 units present a geranium odor occurs. As the numbers increase up to several thousand per cc. the odor becomes fishy. This odor may also be caused by smaller quantities dying. Tabellaria and asterionella in small amounts may cause a distinctly earthy odor also produced by large amounts of synedra. Anabaena and aphanizomenon when present in 500 to 1000 units produce a faint grassy odor. Large numbers cause an odor of a pigpen character. Uroglena produces an oily, fishy taste and odor, first noticeable in probably 500 to 1000 units. In larger quantities it resembles cod liver oil. Synura may cause cucumber odor in amounts as little as 50 units. Water containing the dead organisms has an immediate first taste but no after taste. Microscopic organisms do not affect the health. Organisms will die if reservoir allowed to stand from three weeks to three months. Aeration and treatment with copper sulphate and chlorine employed for destruction of organisms. Copper sulphate in dosage ranging between 0.05 and 1.00 p.p.m. by weight was applied according to species present. Effect of copper sulphate treatment is shown by immediate intensification of distinctive odors, by reduction of number of organisms in water through sedimentation. Sometimes increase in water bacteria occurs. Cyanophyceae may produce scum after treatment, of varied colors, pale blue, yellow, red or brown. Copper sulphate applied in burlap bags, containing 50 lbs., dragged through the water in zig-zag courses. Launches were successfully used in the large reservoirs, treatments being applied over parallel courses 100 feet apart. In Kensico reservoir copper was applied by mechanical means; dry feed method was found very successful. At winter temperature, 0.2 p.p.m. killed asterionella, and, at spring temperature, 0.12 p.p.m. Trouble with synura was overcome by copper treatment plus super-chlorination. It was found that 0.6 to 0.75 p.p.m. of chlorine destroyed the taste, and, after 12 to 24 hours, chlorine could not be tasted.—*N. J. Howard.*

Pittsburg, California, Sued for Typhoid Cases. Bull. Calif. State Board Health, March, 1923; Pub. Works, 54: 197, 1923. (*Cf.* this J., 10: 1140) Court decision gave total of $32,821 in damages to citizens who contracted typhoid fever through failure of chlorinating plant to function on water supply.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Sealing Permeable Foundation of Dam into Grout. W. S. Lea. Contract Record, 1923; Eng. Contrg., 60: 548–50, 1923. Describes method employed on small dams in Quebec to seal foundations on rock without use of cut-off trench. —*Langdon Pearse.*

Filter Plant Operation at St. Louis. E. E. Wall. Ann. Rept. Water Commissioner, 1923. Eng. Contrg., 60: 550, 1923. During year ending April 1, 1923, on average, 112.3 m.g.d. were filtered; at cost of $4.01 per mil. gal. Washing of filters is at rate of 15 gal. per sq. ft. per min. 1.409 per cent of water was used.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

New Water Rate in Saint Paul. J. W. Routh. Pub. Works, 54: 156–7, 1923. In Jan. 1923 new rates went into effect on sliding scale of service charges plus even charge of 6 cents per 100 cu. ft. Details are given. About 70 per cent of supply is metered.—*Langdon Pearse.*

Concrete Lining of Irrigation Canals and Laterals. R. C. E. Webber. Reclamation Record; Eng. Contrg., 60: 539–41, 1923. Cost and economic advantages are cited. With concrete, maintenance is lower and seepage is reduced.—*Landgon Pearse.*

The Bloomington, Ind. Water Supply Problem. Paul Hansen. Indiana San. & W. S. Assn., 1923; Mun. Cty. Eng., 64: 95–100, 1923. Details history, from first supply to present improvement, describing geologic conditions which determined final selection of site of dam and reservoir. Owing to failure of early works, serious water shortage resulted.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Constructing Earth Dams in Vermont. Pub. Works, 54: 80–2, 1923. Two dams, one 200 ft. high, were built for the N. E. Power Co., with cores of fine material deposited by hydraulic method between embankments of earth brought in dump cars.—*Langdon Pearse.*

Delaware River for New York Water Supply. Pub. Works, 54: 87–8, 1923. (*Cf.* this J., 10: 1144) New York City is seeking additional supplies for use after 1935.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Chlorination at Delaware, Ohio. Pub. Works, 54: 88–9, 1923. In spite of continuous use of Cl at high rate (1 to 2 p.p.m.), epidemic of enteritis occurred at Delaware, Ohio. Pollution entering river above intake is a factor.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Proofing on Reinforced Concrete Standpipe. G. C. Brehm. Ann. Rept. Dept. Pub. Works, Waltham, Mass., 1922; Pub. Works, 54: 167–8, 1923. Eng. Contrg., 60: 523–5, 1923. A 16 yr. old concrete standpipe, 100 feet diam, 43 feet high, was water-proofed by drying walls, mopping with asphalt, applying coat of felt, then mopping again, for five successive layers, outside being 6 oz. saturated duck; all mopped with asphalt; covered with 4-inches brick core built up in 6 feet sections. Cost was $16,500.—*Langdon Pearse.*

Repumping vs. Increased Pressures for Fires. Arthur Jensen. Can. Sec. Am. W. W. Assn., 1923; Eng. Contrg., 60: 526–9, 1923, Can. Engr., 44: 534–6, 1923. Motor pumpers or fire apparatus are more economical; 80 per cent of water works do not increase pressure for fires.—*Langdon Pearse.*

Boiler Plant Operation at St. Louis with Fuel Oil. E. E. Wall. Ann. Rept. Water Commissioner, St. Louis, Mo., 1923. Eng. Contrg., 60: 525, 1923. Oil burned cost $0.5263 per 1000 pounds stream, as compared with coal cost of $0.2999; oil was used owing to coal shortage.—*Langdon Pearse.*

Comparison of Lead, Leadite, and Cement Joints. E. E. Wall. Ann. Rep. Water Commissioner, St. Louis, Mo., 1923, Eng. Contrg. 60: 529, 1923. Cement and leadite are better insulators and stand more deflection. Lead and leadite joints can be made at any time. Cement joints are at a disadvantage in winter —*Langdon Pearse.*

Deflection Measurements on Arch Dam in Switzerland. F. A. Noetzli. Schweizerische Bauzeitung, Jan 20, 1923; Eng. Contrg., 60: 530–3, 1923. Describes methods of measurement and calculations of deflection of arch dam in Switzerland on River Reuss, 75 feet high, with a 95.5 chord.—*Langdon Pearse.*

Chicago Diversion Now Paid For. R. I. Randolph. Can. Engr., 45: 315, 1923. Discusses certain claims of Sir Adam Beck with relation to Chicago diversion.—*Langdon Pearse.*

Chicago Drainage Canal. R. I. Randolph. Can. Engr., 45: 317–8, 1923. Discusses article by Holgate, and cites history of canal to show publicity in past covering 10,000 c.f.s.—*Langdon Pearse.*

Improving Wilmington's (N. C.) Water Supply. C. W. Smedberg. Pub. Works, 54: 277–81, 1923. Changes and enlargement of filter plant, relocation of intake, and installation of motor-driven pumping plant, furnish better water at a saving in cost which pays for improvement. Details of intake pipe, submarine connection, and remodelling, are given.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Cleaning Water Mains in Manhattan, Kansas. B. L. Ulrich. Kansas Municipalities, June, 1923; Pub. Works, 54: 281–2, 1923. Water has hardness of 450 p.p.m., and iron, 7 to 10 p.p.m. 7.8 miles of pipe were cleaned at cost of 11.6 cents per foot. Cleaning machine was drawn through by cable.—*Langdon Pearse.*

Benton Harbor Purification Plant. Pearse, Greeley and Hansen. Pub. Works, 54: 285 9, 1923. This 2 m.g.d. plant treats both river and well water carrying iron. Arrangement is made for overdosing part of water, but this has not proved advantageous. Dorr thickener is used for preliminary sedimentation (1 hour); followed by 8 hours in 2 basins. Return sludge from Dorr Clarifier aids sedimentation.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

The Hetch Hetchy Dam Completed. C. W. Geiger. Pub. Works, 54: 302–4, 1923. Eng. Contrg., 60: 256–7, 1923. Summarizes salient features of structure; arch dam, 700 feet radius; height, 341 feet; cost, $5,500,000.—*Langdon Pearse.*

Water Purification at Columbus. C. P. Hoover. Ann. Rep., 1922; Pub. Works, 54: 305, 1923. Eng. Contrg., 59: 1035–6, 1923. Effect of temperature on softening reaction discussed in connection with reaction time. Use of CO_2 for carbonating softened water is being tried, using various devices.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Wastes, Meters and Rates at Baltimore. V. B. Siems. Eng. Contrg., 60: 261–70, 551–62, 1923. Describes water waste survey made of high, low, and middle services. Inspections and pitometer surveys were used, cutting down waste in four (4) districts in amounts varying from 825,000 to 2,000,000 g.p.d. This has benefited sewage treatment works. Consumption in Baltimore is increasing. Only 11.3 per cent metered. Average daily consumption is 125 gallon per cap., divided into: commercial and industrial, 34.6 gal.; public and municipal, 10 gal.; waste, 13 gal., and domestic, 67.4 gal. Metering program is outlined, with costs, rates, and comparisons in detail.—*Langdon Pearse.*

Preparation of Water for Filtration. F. A. Dallyn and A. V. Delaporte. Can. Sect. Am. W. W. Assn.; Eng. Contrg., 60: 271–4, 1923; Can. Engr., 44: 474–6, (*Cf.* this J., 10: 1138). Intake should not be subject to gross pollution. Use of pressure filters is permissible with suitable laboratory force, on Great Lakes water; but not on highly resistant water. Optimum condition of water is important. Sedimentation of at least 2 hours is advantageous. To remove excess CO_2, following use of $Al_2(SO_4)_3$, Na_2CO_3 may be used. In iron bearing waters, chemicals other than alum may be required.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

The Siphon Spillway on the O'Shaughnessy Dam. G. F. Stickney. Eng. Contrg., 60: 574, 1923. Eighteen (18) siphons are provided with total capacity of 20,000 C. F. S.—*Langdon Pearse.*

Blasting Frozen Ground in Excavation for Dam Foundation. Reclamation Record, June 1923; Eng. Contrg., 60: 578, 1923.—*Langdon Pearse.*

The New Well Water System of Camden, N. J. J. H. Long. Eng. Contrg., 60: 258–9, 1923. Four (4) wells, sunk in sand, yield about 6,500,000 gal. per 24 hours.—*Langdon Pearse.*

Locating Leaks in Underground Pipe Lines, with Geophone. H. A. Ward. Mechanical Engineering; Tech. Paper 277, U. S. Bureau of Mines; Eng. Contrg. 60: 89, 1923.—*Sangdon Pearse.*

Comparison of Flood Control Measures. Harry Taylor. Am. Assn. Adv. Science, 1923; Eng. Contrg., 60: 563–7, 1923.—*Langdon Pearse.*

Economics on Cleaning Irrigation Canals. C. L. Tucker. Reclamation Record, 1923; Eng. Contrg., 60: 568–72, 1923.—*Langdon Pearse.*

Rapid Sand Filtration Plant Operation. W. D. Hatfield. Can. Sect. Am. W. W. Assn., 1923; Eng. Contrg., 60: 74–6, 1923; Can. Engr., 44: 539–40, 1923. Simple description; non-technical.—*Langdon Pearse.* (*Courtesy Chem. Abst.*

A Water Borne Typhoid Epidemic of Unusual Character. C. K. Blanchard. Pub. Health News (N. S.): Eng. Contrg., 60: 81–2, 1923. At Franklin, N. J., outbreak was caused by contamination through leaky check valve on special fire service.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Constructing Mitchell Dam. L. G. Warren. Pub. Works, 54: 247–50, 1923. Describes construction of gravity concrete dam on Corsa River in Alabama: cofferdams built in wide, swift, stream, with stone-filled timber cribs, clay being deposited for water seal.—*Langdon Pearse.*

The Corrosion of Underground Structures. E. R. Shepard. Mun. Cty. Eng., 64: 51–3, 1923.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

The Resuscitation of a Water Company. Farley Gannett. Mun. Cty. Eng., 64: 72–6, 1923. Story of repairing leaky dam impounding water for small town supply.—*Langdon Pearse.*

Why Mt. Pleasant, Mich. paid $39,750 for a $15,000 Water Improvement. C. H. Peterson. Mun. Cty. Eng., 64: 85–6, 1923.—*Langdon Pearse.*

Effect of Feed Water Heating on Plant Economy. G. G. Bell. Mechanical Eng., 45: 7, 417, July, 1923. Studies of plant equipped with 30 K. W. units, clearly indicating advantages of bleeding main turbine, in plants either with, or without economizers.—*E. E. Bankson.*

Concrete Pipe Plain and Reinforced. Jos. S. Lambie. Engineers' Society of Western Penna., 38: 10, 471, January, 1923. Proper methods of testing pipe and description of "Machine Made" concrete pipe wihh numerous discussions and questions.—*E. E. Bankson.*

Design of Earth Dams. Joel D. Justin. Proceedings Amer. Soc. C. E., 49: 5, 856, May, 1923. Practical criteria for design of earth dams. Design should be such that:—(1) Spillway capacity is so great that there is no danger of over-topping; (2) Line of saturation is well within down-stream toe, and also

well below surface of original ground below dam; (3) Up-stream and down-stream slopes are such that with materials used in construction, they will be stable under all conditions; (4) There is no opportunity for free passage of water from up-stream to down-stream face; (5) Water which passes through and under dam, has, when it rises to surface below toe, velocity so small that it is incapable of moving any of material of which dam or its foundation is composed; (6) Freeboard is such that there is no danger of overtopping by wave action. Factors affecting position of line of saturation are given in detail; also movement of under-ground water, and its relation to design of earth dams. An equation is developed which will determine position and slope of line of saturation in dam and a variety of actual problems are worked out. Each criterion is thoroughly discussed and explained; for example, slope for up-stream face of dam should generally be determined by angle of repose of material when under water, being made flatter than that indicated by experiments as safe, and in general, not steeper than half that at which same material would stand out of water. Slope of down-stream face should be flatter than angle of response of material. Many protection methods are well discussed. Freeboard must include allowance for maximum height of floods. For greatest "Flood Flows" see transactions A. S. C. E., 77: 564 1914. Table of statistics given, for 120 successful earth dams, from 25 to 240 ft. in height. To be safe, any earth dam must meet each and all of these criteria. **Discussion.** J. E. Fields, J. C. Stevens, and J. D. Austin. Ibid. 49: 9, 1874. November, 1923. Valuable discussion on original paper, including additional data. Table on failures and partial failures of earth dams; curves and table to find volume of earth dams for various heights and slopes; table of maximum recorded floods in American rivers.—*E. E. Bankson.*

Tentative Plan for the Construction of a 780-Foot Rock Filled Dam on the Colorado River at Lees Ferry, Arizona-Discussion. C. A. LaRue. Proceedings Amer. Soc. C. E., 49: 5, 942, May, 1923. Results of detailed survey, are compared with preliminary estimates in original paper, with comments on discussion by other members.—*E. E. Bankson.*

Improved Type of Multiple-Arch Dams. Fred A. Noetzli. Proceedings Amer. Soc. C. E., 49: 6, 1065, August, 1923. Describes multiple-arch dam of improved type, in which each buttress pier consists of double walls stiffened by cross walls. No multiple-arch dam has ever failed. It is essential that foundation of a multiple-arch dam be impervious by nature, or be made so by grouting. Full theory of design is given, and cases cited. A well designed multiple-arch dam, with double wall buttresses, may be built economically to height of 200 ft. and more; is structure, the stability and safety of which are beyond doubt. Danger of up-lift is practically eliminated. The multiple-arch dam involves less excavation than gravity type, less time for construction, less hazard from floods during construction; can be built with architectural appearance that affords beauty with impression of strength.—*E. E. Bankson.*

Stresses in Multiple-Arch Dams. B. F. Jakobsen. Proceedings Amer. Soc. C. E., 49: 6, 1093, August, 1923. Complete discussion of stresses in multi-

ple-arch dams, with full theory and examples. Writer concludes that stresses should be determined with greater precision than in the past; and that higher dams can be built safely, and high stresses can be used.—*E. E. Bankson.*

Chlorine Control (for Water Purification, etc.) Apparatus for. J. W. VAN METER. E. P. 199,052, 12. 12. 21. Chem. & Ind., 42: 854A, Sept. 7, 1923. Apparatus comprises dome-shaped body, fitted to closed transparent vessel below in which is supported graduated inverted funnel. Lower vessel is filled with liquid (e. g., paraffin, if dry chlorine is required; or water, if chlorine water is to be supplied). Chlorine enters funnel from above, depressing liquid to a predetermined level, and escapes from port in side of funnel, passing through liquid in outer vessel in bubbles which can be regulated. To deliver chlorine water, the paraffin is replaced by water, which is sprayed into the upper dome continuously. Flow of gas is regulated as before. (A. G. P.).—*A. M. Buswell.*

Deaeration and Degasifying of Water and Other Liquids. D. B. MORISON. E. P. 199, 748, 23.12.21 and 4.4, 14.6, and 14.7, 22. Chem. & Ind., 42: 855A, Sept. 7, 1923. In physical process for deoxidising and degasifying liquids, more especially boiler-feed water, continuously flowing body of water, during its passage through deaerating chamber or chambers, is repeatedly raised to, and maintained at, boiling temperature, at any desired absolute pressure, by means of steam jets or nozzles provided at different points in line of flow. Arrangements are provided for discharge of gases evolved. The water is passed through condenser before being admitted to deaerator vessels, which are each provided with means for controlling pressure therein. Between the different vessels drop in temperature of water is caused by coil or the like. Provision is also made for interchange of heat between discharged and incoming water. Suitable valves allow for deaerators or degasifiers to be maintained under vacuum, but at different absolute temperatures (E. M. V.).—*A. M. Buswell.*

Rapid Gasometric Method of Estimating Dissolved Oxygen and Nitrogen in Water. H. G. BECKER AND W. E. ABBOTT. Sci. Proc. Roy. Dublin Soc., 17: 249–253, 1923. Chem. & Ind., 42: 1041A, Nov. 2, 1923. Air dissolved in water is set free by dissolving in the water a highly soluble substance; potassium hydroxide has been found the most effective. Water to be tested is saturated in bulb with potassium hydroxide and air set free is collected and measured. Oxygen is then absorbed in alkaline pyrogallol and residual nitrogen measured. Method is rapid and requires only 20–30 cc. of water. Total air found is slightly higher than by other methods, due to air in potassium hydroxide; whilst oxygen found is slightly lower, owing to incomplete absorption. Method has only been tested with distilled water, but should be applicable to natural or polluted waters (E. H. R.).—*A. M. Buswell.*

Treatment of Peat for the Softening of Water. G. G. HEPBURN. E. P. 197,851, 20.6.22. Addition to 173,255 (J. 1922, 193A). Chem. & Ind., 42: 854A, Sept. 7, 1923. When peat which is to be used for softening of water is

treated with alkali to remove soluble matter, and to produce insoluble alkali salts in peat, it increases very largely in bulk, when immersed in water; but if peat is washed and dried before being immersed this bulking does not take place. (J. H. J.)—*A. M. Buswell.*

Micro-sampling for the Determination of Dissolved Oxygen. R. V. Allison and J. W. Shive. Soil Sc., 15: 489–491, 1923. Chem. & Ind., 42: 1042A, Nov. 2, 1923. Modified Winkler apparatus is described for sampling of liquid media in which dissolved oxygen is to be estimated (G. W. R.).—*A. M. Buswell.*

Method of Water Purification. W. F. Langelier. U. S. P., 1,465, 137, 14.8.23. Appl., 25.2.20. Chem. & Ind., 42: 1042A., Nov. 2, 1923. In usual method of water or sewage purification by addition of soluble aluminum salt to coagulate suspended matter, coagulation and sedimentation are hastened and amount of aluminum salt required is much reduced if small quantity of an acid, such as sulphuric acid, or an acid salt, such as sodium bisulphate, be simultaneously added.—*A. M. Buswell.*

Irregularities in the Rate of Solution of Oxygen by Water. H. G. Becker. and E. F. Pearson. Sci. Proc. Roy. Dublin Soc., 17: 197–200, 1923. Chem. & Ind., 42: 1042A, Nov. 2, 1923. Rate of solution of oxygen at surface of still water under constant conditions follows same logarithmic law as if water were being constantly mixed, up to point where water is 60–70 per cent saturated. Beyond this point rate of absorption is irregular (E. H. R.).—*A. M. Buswell.*

Report on Trade Refuse (Coal Trade) in the West Riding. H. MacLean Wilson. Reprint. In discharges from 85 collieries today there is danger of stream pollution. In 65 of these there are coal washers; in 45, a chemical plant. In many cases there is danger from blowing off boilers, water softening, and escapes of oil. Pollution by coal washing water has been comparatively easy to deal with; effective settlement generally produces an innocuous effluent; but quantity of sediment produced is so large that constant care is needed to keep settling tanks clean and effective. Recently, in several cases, colliery owners have been persuaded, with good results, to use automatic and mechanical means for separating and removing sediment. Pollution by chemical discharges, such as waste waters from recovery of ammonia, extraction and purification of benzol, etc., which, it will be noted, are processes new in connection with collieries since 1896, is not so easy a matter to deal with, and has at times caused the Board great trouble. Three methods have been found useful in preventing this pollution. In 20 cases, chemical refuse is used up for quenching coke; in 12, it is disposed of by irrigation upon a spoil bank generally burning; and at 8 collieries, it is discharged into old pit workings. In one case, it is mixed with water used for coal washing, and in one case it is discharged into the public sewer.—*A. M. Buswell.*

Water Works Plant at Woodbridge, Ontario. W. B. Redfern. Can. Eng., 44: 21, 520, May 22, 1923. Supply obtained from open well, 50 feet from Humber River. At 14 feet depth water filters through bed of sand into a

well. 100,000 gallon standpipe when full gives town pressure of 55 lb. per sq. in. Water for fire can be drawn from well and standpipe simultaneously.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Report of Committee on Water Supply and Water Purification. Public Health Bulletin 133, U. S. Public Health Service, May 1923. Recommends endorsement of proposed amendment prohibiting discharge of polluting material from vessels while in vicinity of public water supplies; suggests consideration of amendment concerning use of watertight storage containers; regulation concerning quality and handling of ice effective until July 1, 1924, is advised. —*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Hydrogen Ion Concentration of Natural Waters in Relation to Disease. W. R. G. Atkins. Journal State Medicine, **31**: 5, 223, May 1923. With exception of bog waters and waters abnormally rich in metallic salts, naturally occurring water are at pH favorable to continued existence of Vibrio Cholerae and typhoid bacilli. Suggestion made that water be made safe by making as alkaline as pH 10.5 by addition of ash from vegetable matter rich in carbonates of potassium and sodium.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Purification of Drinking Water in the Field. Lt. Col. J. A. Anderson. Jour. Royal Army Medical Corps, **40**: 6, 401, June 1923. Standard British Army purification method is addition of alum (5 g.p.g.) formation of aluminium hydroxide and its removal by sedimentation or filtration through sand or fabric. Sterilization by addition of one part per million of free chlorine, contact 20 to 30 minutes and dechlorination as required by sulfur dioxide, sodium thiosulfate or sodium sulfite. Purification by iodine, acidification and use of tablets described.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Report of the Committee on Limitation and Control of Chlorination of Water. Trans. 3d Annual Conference State Sanitary Engineers, U. S. Public Health Service Bulletin 133: 19, May, 1923. Report is an argumentative defense of chlorination for sterilization, stating that it is commonly an irregular, haphazard treatment, little understood and poorly controlled.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Rules and Regulations for Swimming Pools. Jour. American Association for Promoting Hygiene and Public Baths, **5**: 61, 1923. Complete rules and regulations for swimming pools and bathing places as adopted by Arkansas, Louisiana, New Mexico, West Virginia, Idaho, Tennessee, Virginia and Washington State Departments of Health.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Report of Conference on Phenol Wastes. U. S. Public Health Service, 11 pages. 1923. Phenol waste problem in United States discussed. Closed disposal system for treating coke wastes by evaporation most promising. Motion passed requesting U. S. Public Health Service to investigate problem from standpoint of public health, and Bureau of Mines to look into economic side of question.—*A. W. Blohm.* (*Courtesy Pub. Health. Eng. Abst.*)

Meter Installations and Meter Rates. E. I. Roberts. Pamphlet by Ohio State Department of Health. 1923. Increased cost in operation of water works brought about study of Ohio cities and villages with metered and unmetered supplies. Study indicates average daily consumption of 90 gallons per capita for 100 per cent metered services and 170 gallons per capita for unmetered services. Table and charts show per capita consumption and water rates.—*A. W. Blohm.*

A Study of the Effect of Gentian Violet on the Viability of Some Water-Borne Bacteria. Esther Wagner Stearn. Am. Jour. Public Health, 13: 7, 567, July 1923. Results of using broth containing gentian violet as inhibiting agent in comparison with other media for determining B. Coli in drinking water. Conclusion: does not inhibit vigorous growth of B. Coli or other important lactose fermenting water-borne bacteria.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Suppression of Corrosion by Removal of Gases. Bulletin (French) issued by Union Thermique, 19 Boulevard Malesherbes, Paris. Corrosion of metals by water containing oxygen and removal of oxygen by passing through deactivating tanks containing specially prepared iron arranged in beds through which water must pass several times.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

The Post Swimming Pool. Major James C. Magee. M. C. Military Surgeon, 52: 5, 524, May, 1923. Army Pools regulated to avoid unnecessary pollution of water. Chlorine commonly used for disinfection, dose of 0.5. p.p.m. being maintained.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

Flow in California Streams. Bulletin No. 5, Appendix "A" to Report to Legislature of 1923 on Water Resources of California, Department of Public Works, Sacramento, California, 1923. Report contains 175 tables and 185 plates on precipitation, run-off, probable frequency of flood discharge, and storage developments.—*A. W. Blohm.* (*Courtesy Pub. Health. Eng. Abst.*)

Water Resources of California. Bulletin No. 4, Department of Public Works, Sacramento, California, 1923. Run-off from principal streams of state and comprehensive plan to obtain maximum service. Utilization and development of water resources discussed.—*A. W. Blohm.* (*Courtesy Pub. Health Eng. Abst.*)

The Emergency Treatment of Water for Drinking Purposes. A. P. Hitchens The Military Surgeon, 51: 657, 1922. Work of L. T. Fairhall and C. B. Wood, on treatment of water in Lyster bags, is reviewed, and procedure suggested, based on observation that, in test for free chlorine, change from lemon yellow color to orange occurs within surprisingly narrow limits. With 0.75 cc. of standard o-tolidin, threshold is very close to 1 p.p.m. chlorine. the recommended excess. Within limits, the smaller the amount of reagent added, the deeper the color produced with same concentration of chlorine. Emergency treatment of water with iodine (J. J. Hinman. Univ. of Iowa Monographs.

Studies in Medicine, Aug., 1918) is outlined. Five cubic centimeters standard tincture (7 per cent) in a Lyster bagful, 1 drop per quart, will render even raw Potomac River water safe for drinking in 30 min. As in case of chlorine, excess iodine may be removed by addition of 1 gram sodium thiosulfate.—*R. E. Thompson.*

Storage Yards of the Detroit Water Department. C. P. McGrath. Amer. City, 29: 226-30, 1923. Description of the four service yards maintained: for pipe, specials, valves, and maintenance material. Methods of handling breaks, taps, and meters given. Special equipment, such as unloading cranes, motorized valve operating truck, trailers for tools, etc., are described. Department maintains repair shop for 78 automobiles. Detroit has over 160,000 meters in service; of which, last year, 6400 were repaired, and 47,500 tested; while 700 new meters were set.—*W. Donaldson.*

The Economics of Sewage Disposal. H. Burdett Cleveland. Amer. City, 29: 235–6, 1923. Capital investment in sewage treatment works should be governed by actual need, rather than by desire for complete purification, which may not be justified by benefits to be gained.—*W. Donaldson.*

From Red Ink to Profits. John Oliphant. Amer. City, 29: 237–8, 1923. Galva, Ill., by replacing steam equipment with oil engine for its well supply, and improvements to air lift, has converted monthly deficit of $300 to $500 to profit of $500 to $600, in spite of rate reduction of 15 per cent. Cost and efficiency figures given.—*W. Donaldson.*

Pure Drinking Water in New York State. Editorial. Amer. City, 29: 238. 1923. According to Division of Sanitation of New York State Department of Health, 9,182,000 of the 10,651,000 people who live in State of New York are now supplied with drinking water from public water supplies, and 7,796,000 drink water that has been sterilized.—*W. Donaldson.*

Constant Vigilance Reduces Water Waste in Ottawa, Canada. H. D. Hoolihan. Amer. City, 29: 258, 1923. Water-waste durvey made in 1912–13, cost $10,300.00. Subsequent survey of distribution system with pitometer photo recorder has been carried on by force consisting of one foreman and six men with three house-service inspectors to follow up defective plumbing. Since 1919, 764 leaks in services and mains have been stopped, with estimated saving of 8 to 10 mgd. (Imp). Per capita consumption has decreased from 189 in 1913 to 173 gallons (Imp) in 1923. Present population supplied with water is 116,205, consumption is 21 mdg. (Imp.), with 10 per cent metered.—*W. Donaldson.*

What is the Index of Stream Pollution? Anon. Amer. City, 29: 264, 1923. Comment on recent bulletin of U. S. Public Health Service regarding self-purification of the Ohio River, discussing relation of plankton and other aquatic life to stream pollution.—*W. Donaldson.*

Types of Meter Rates. ANON. Amer. City, 29: 270, 1923. Tabulation by Detroit Water Department classifies meter rates used by American Cities as follows: (a) Uniform Minimum Rate, which entitles user to stated quantity; (b) Service Charge, made in addition to charge for water; (c) Graduated Minimum Rate, in which minimum increases with size of meter; (d) Sliding Scale, with or without minimum rate, or service charge. Majority American Cities use sliding scale with minimum charge, N. E. Water Wks. Assn. recommends minimum service charge.—*W. Donaldson.*

Convert Water Waste into Profit. C. C. BEHNEY. Amer. City, 29: 274, 1923. Assumes that 15–50 per cent of total pumpage is preventable waste, due to, (a) Underground leakage, (b) Fixture leakage, (c) Wanton waste, and (d) Underregistration of meters. As results of surveys, Hagerstown, Md., pop. 29,000, daily consumption 4.1 mg., 75 per cent metered, reduced a per capita consumption of 141 gals., to 120; and Lexington, Ky., pop. 45,000, 100 per cent metered, per capita consumption 100 gpd., found 0.7 mgd. leakage, repair of which brought per capita consumption to 82 gpd., of which 42 gpd. was industrial.—*W. Donaldson.*

Will It Pay to Burn Oil Instead of Coal? W. F. SCHAPHORST. Amer. City, 29: 375–6, 1923. Presenting a graphic solution to the problems.—*W. Donaldson.*

The New Well Supply of Waupaca, Wisconsin. W. G. KIRCHOFFER. Amer. City, 29: 460–3, 1923. Unsatisfactory surface supply has been replaced by shallow ground water gotten in unique way, sinking cylindrical concrete caisson, or collecting well, 37.5 ft. deep, 30 ft. inside diameter, and 18 in. thick, by excavating inside with a clam-shell bucket. Bottom of caisson was constructed with cutting edge of concrete to make a hole 8 ft. larger in diameter than itself, this space being filled with gravel as the sinking progressed, forming a strainer against entry of sand. Six ports, 5 ft x 3 ft. pierce the concrete cylinder to allow entrance of ground water, openings being covered with porous screen, 6 in. thick, of grouted gravel. Yield of collecting well is estimated at 700 gpm. Cost was $11,200.00.—*W. Donaldson.*

Oxyacetylene Welding in Artesian Well Work. ANON. Amer. City, 29: 499–500, 1923. (Reprint from "Oxy-Acetylene Tips.") Methods of welding 18 in. and 24 in. steel well casing are described.—*W. Donaldson.*

Filtration and Chlorine versus Typhoid Fever. CHARLES STREITHOF. Amer. City, 29: 507–8, 1923. Traces development of the water works at Evansville, Ind., from first installation, in 1871, to present time. Detailed figures show decline in typhoid incidence with increasing use of city water, and improvements in water purification and general sanitation. In 1908, with 41 per cent of population served, and no water purification, there were 213 cases of typhoid; in 1922, with 95 per cent population served with filtered and chlorinated water, there were only 7.8 cases per 100,000.—*W. Donaldson.*

Modern Equipment Augments an Old Municipal Water-Supply. C. W. Melcher. Amer. City, 29: 585–6, 1923. (Reprint from Compressed Air Magazine.) Prior to 1916, the spring supply of Elmhurst, Ill., was distributed through wooden mains installed in 1886. Drilled wells, 975 ft. and 1400 ft. deep, are the present source. Improvements made by municipality, since taking over works from private company in 1920, include complete cast iron distribution system and new power-house with oil engines for driving air compressors, pumps, and generators. Water is pumped from wells by air lift into surface reservoir, then repumped with centrifugals into distribution system and elevated tank. Combined capacity of the two wells is 1250 gpm. Replacement of deep well pump in 975 ft. well by air lift increased yield from 185 to 630 gpm. Main power unit is a type PO oil engine of 73 B. H. P. Fuel cost of raising water from wells and delivering to mains against 43 lbs. pressure is 0.87 cents per 1000 gals. with oil at 5½ cents per gallon.—*W. Donaldson.*

The Water Works of Elyria, Ohio. Anon. Amer. City, 29: 587–91, 1923. Illustrated description; particularly of improvements installed in 1920–23. Supply taken from Lake Erie through wooden crib and 1500 ft. of 24 in. pipe. Low-lift steam turbine driven centrifugals deliver to 8.0 mgd. purification plant, consisting of (a) baffled mixing chamber of 20 minute retention period; (b) twin coagulating basins, each 39 × 196 ft. × 16 ft. deep, with retention of 4.5 hours; (c) four filter units of 2.0 mgd. capacity each; and (d) covered clear water storage of 1.0 mg. capacity. Crank and fly-wheel pump delivers filtered water to city. Interesting features are boiler plant equipment, dry feed machines (3) for lime and iron, or lime and alum, float valve control on coagulating basin inlet, arrangement of the ten basin sludge valves, Venturi tubes on basin inlets to proportion flow, master filter effluent control operated by level in clear basin, in addition to individual filter control. Elyria distribution system embraces 65.4 miles of 4 in. to 20 in. pipe. Value of works as of Dec. 1920 was $2,000,000, one-half of which is represented by distribution system. Revenue from water during 1922 was 17.4 cents per 1000 gallons.—*W. Donaldson.*

A Million Dollar Water Supply for a City of 18,000. Cora Moore Cameron. Amer. City, 29: 598–9, 1923. Inadequacy of small impounded supply and unsuitability of local ground water led to development of new supply by damming Pine Creek, installing new pumps, filters, and 0.5 mg. elevated tank in city. Dam is 3125 ft. long and 30 ft. high, with reinforced concrete spillway 200 ft. long. Catchment area is 48 sq. mi.; reservoir holds 4 billion gallons and submerges 1300 acres.—*W. Donaldson.*

Water Supply Conditions in Jerusalem. Anon. Amer. City, 29: 608–9, 1923. Acute water shortage reported, due to growing population. Present supply is rain water, caught in cisterns in city, supplemented by water from a cavern 13 miles south of city at head of Wadi Biarfi. Tunnels through the rock bring the spring water to storage in the three Pools of Solomon, ten miles south of city. Much repair work has been done recently to clear tunnels of debris and put two of storage reservoirs in condition. Work on third pool

is deferred. Combined capacity of the three pools will be 40 mg., equal to three months' supply for whole city.—*W. Donaldson.*

For Shorter Spacing of Fire Hydrants. William R. Conard. Amer. City, 29: 643–5, 1923. Writer favors spacing hydrants at 100-foot intervals, instead of average 500 ft. in vogue. Presents comparative figures to show advantage, from standpoint of capital investment, of shorter spacing, which saves large outlays for hose and fire engines, besides giving better fire-fighting facilities.—*W. Donaldson.*

Sanitary Problems of Growing Villages. George C. Whipple. Amer. City, 29: 400–1, 1923. Four transition stages in water supply and sewage arrangements are outlined as follows: (a) primitive rural, (b) advanced rural, (c) primitive urban, and (d) advanced urban. In the last stage, public water supply and public sewers replace cruder facilities. Simple sketches illustrate the text.—*W. Donaldson.*

Design, Operation and Accomplishments of the Stream-Line Filter. George W. Fuller. Chem. and Met. Eng., 29: 1006, 1923. Stream-line filter is invention of H. S. Hele-Shaw; is made of pack of specially prepared paper, impervious to water and oil, and roughened to provide passageways; pack is held within a container, between two press-heads. At one press-head are channels through which influent is led to each of the openings of larger diameter, and at other press-head are channels connecting with smaller holes to remove effluent. Effluent, even under heavy pressure, can pass from larger tubular openings only between laminae of heavily compacted paper, with stream line flow, into smaller tubular openings which form exit from filter. It is essential that material used have rough surface, so as to provide passageways. Passing certain mixed liquids through filter several times, with increasing pressure on pack each time, different substances are removed at each filtration. Some of the accomplishments are: removal of color from water; production of clear and nearly tasteless fluid from milk; extraction of oil from feed water; and reduction of dilute activated sludge to 60 per cent water content.—*John R. Baylis.*

Edge Filtration. Chem. and Met. Eng., 29: 932, 1923. Principle upon which this device operates, is called edge filtration; is invention of Dr. Hele-Shaw. Liquid being filtered does not pass through porous filtering medium, but, in thin films, between laminae of material. A paper that has slight matt to its surface is used, so that, no matter how tightly the sheets are pressed together mechanically, minute passages for liquid remain. Sheets have two sizes of holes; influent liquid, entering larger ones, passes between the sheets, and out through smaller ones. It is rather a clarifier, than filter proper. Several figures, showing details of filter, are given.—*John R. Baylis.*

The Use of Aluminum to Prevent Steel Corrosion. Arthur V. Farr. Chem. and Met. Eng., 29: 1188, 1923. Aluminum alloy surface is produced by heating material in reducing atmosphere containing finely divided aluminum. Mate-

rials so treated have the advantage of their original structural strength unimpaired, together with corrosion resistance of aluminum. Aluminum is less active chemically than zinc; hence this treatment should offer better protection to metals than sherardizing.—*John R. Baylis.*

Flow of Fluids—How Electric Motors Should be Applied to Pumping Equipment. R. H. Rogers. Chem. and Met. Eng., 29: 928–31, 1923. Selection of motors for most successful operation under all conditions and circumstances is not a simple problem. A desirable characteristic in centrifugal pumps is that of having load fall off each way from best operating point. This prevents overload coming on motor, either by an accident, or by mishandling of valves. Centrifugal pumps are rated at their best operating point; any deviation in speed, head, or delivery, will result in higher cost per unit duty. Operating at lower than rated head should be avoided if possible. For constant speed service, either induction motors of squirrel-cage type, or synchronous motors, may be used. When direct current is used, the shunt-wound motor is not well adapted to centrifugal pump drive: a compound motor should be used with only a moderate series field. For adjustable speed pump drives, wound-rotor motors, or brush shifting, commutator type may be used. Squirrel-cage motors can be used on centrifugal pumps up to 500 h.p. Synchronous motors are not usually installed below 75 h.p. Reciprocating pumps, rotary pumps, and screw pumps, have heavy starting duty; and squirrel-cage motors cannot be used, if line disturbance is objectionable. Squirrel-cage motors are controlled by manual or automatic compensators. Automatic compensator may be actuated by push button, float switch, thermostat, or by diaphragm pressure switch. Wound-rotor motors for constant speed are controlled by automatic panel actuated by push button, float switch, or the like. Synchronous motors are usually controlled by compensator and field discharge switch.—*John R. Baylis.*

Internal Treatment of Boiler Water—Proper and Improper. D. K. French. Ind. Eng. Chem., 15: 12, 1239, Dec. 1923. Enormous amount of data, experience, and even *imagination*, called for. It is possible, by correctly applying small amount of material inside, to produce an effect which would require many times that quantity, if added outside. Organic compounds, which retard precipitation in the cold, are found to aid it at the high pressure and temperature in boiler. *Scale Formation.* With calculated concentration of organic matter in boiler, crystalline separation can be prevented. While sludge may be objectionable, its removal is much easier. Economy in softening chemicals is possible, if balance between them and controlling organic matter is properly adjusted. Organic matter, properly applied, may render crystalline deposits amenable to slow removal without discontinuing boiler operation. Certain inorganic chemicals, sodium silicate being best example, may produce same effect when conditions indicate addition of organic matter as undesirable. Silicate of soda is frequently sold as boiler compound. Used alone, its efficiency is low. Its reaction is little understood. Sellers claim that it treats the metal, not the water: this claim has been proven to be untrue. *Corrosion.* Concentration of soluble salts causing electrolytic action, CO_2 and

oxygen, are most common corroding agents. Inorganic chemicals seem not to have any effect on dissolved oxygen. CO_2 can be removed by lime. Organic acid compounds tend to retard caustic embrittlement by alkaline water. Corrosive gases, especially oxygen, are absorbed; and electrolytic corrosion, reduced. Alkaline tannates, applied to waters of low alkalinity, produce similar results. Chromates and dichromates are frequently used where organic matter cannot be applied. Composition of boiler water, after varying periods of operation, when using organic treatment, cannot be even approximated volumetrically. Organic matter interferes with ionization. *Foaming.* A problem, almost purely, of surface tension. Outside treatment offers nothing to control. Soluble inorganic salts and some organic compounds toughen surface film and thereby increase foaming. A combination of these is most serious; and suspended matter, in addition, will raise water level to dangerous degree. Incomplete precipitation of carbonates of lime and magnesia may cause serious foaming. Organic internal treatment will sometimes definitely retard foaming. In contrast with other oils, castor oil may, under proper conditions, markedly control foaming. By combining precipitation outside with proper anti-foam treatment inside, even the poorest water may be used with fair satisfaction. *Boiler Compoumds.* Attention is called to compounds of undesirable types, and to methods used to advertise them. So-called "metal treatment" types consist almost invariably of sodium silicate solution sometimes colored with dyes. They have been tried and emphatically condemned by the U. S. Government. The insoluble type of boiler compound consists, practically always, of tri-calcium phosphate, talc, aluminum phosphate or some similar compound. Only true benefit derived from their usage is production of more bulky and less crystalline deposit. Soluble compounds in solid form include tri-sodium phosphate, soda ash, or mixtures of these with tannin, etc. *Graphite.* Being electropositive to iron, causes solution of the metal without being itself affected. "Graphite is a scale remover for same reason that hydrochloric acid is. That is, it corrodes metal under scale and frees scale from metallic surfaces." (Jour. Soc. Naval Engrs., 1911.) The same article classifies graphite as a "Dangerous Compound."—*Linn H. Enslow.*

Determination of Carbon Dioxide in Mineral Waters, etc. J. Cannizzaro. Ind. Eng. Chem., **15**: 10, 1074, October, 1923. Rapid and accurate determinations of CO_2 content of highly charged waters, beverages, etc., may be made by following procedure. Sample is kept chilled in ice, to avoid loss of CO_2 when opening bottle. To measured quantity of standard Na_2CO_3 solution, free of bicarbonates, add measured portion of sample, and mix gently. With standard acid, titrate, using phenolphthalein, and methyl orange indicators, thus determining residual Na_2CO_3, and that converted by CO_2 present to $NaHCO_3$. (Above method in general may be applied to collection of water samples of high CO_2 content in cases where CO_2 cannot be titrated at sampling point. The Na_2CO_3 solution should be free of $NaHCO_3$, or else amount present pre-determined. Separate sample of 200 ± cc. is collected for CO_2 determination. With each sample bottle, send small slender vial containing known quantity of standard Na_2CO_3 solution. Fill sample bottle almost full; remove vial stopper, and drop both stopper and vial into sample. Mix sample and

Na_2CO_3 solution by gently inverting a few times after replacing stopper of sample bottle. Sample is now ready for shipment to laboratory. Large excess Na_2CO_3 is undesirable. A good grade of flint-glass sample and reagent bottles must be used.—ABSTR.)—*L. H. Enslow.*

Effect of Deaeration of Natural Waters on the Carbonate Equilibrium. D. H. JACKSON AND J. R. MCDERMET. Ind. Eng. Chem., 15: 9, 958, Sept., 1923. Following results observed during operation of spray-cascade type of commercial de-aerator operating in vacuum and handling water at 140°F. or higher. Carbon dioxide was completely removed. Bicarbonates were partially decomposed, percentage of decomposition varying directly as content of raw water: average 35 per cent. Result was water of high pH value, containing from 10.5 to 15.5 p.p.m. $CaCO_3$. Most of the calcium originally present in the 35 per cent decomposed bicarbonates, precipitates. Hydrogen Ion Concentration was lowered from pH 6.85 (and less) to pH 8.8 to 9.5. Observed pH values, obtained colorimetrically, were in fair agreement with theoretical, as obtained from formula $H^+ = 6 \times 10^{-11} \times \frac{\text{Bicarbonate } CO_2}{\text{Carbonate } CO_2}$, where H^+ = hydrogen ion concentration and respective CO_2 values are in parts per million.—*Linn H. Enslow.*

Preliminary Examination of Water Samples. W. D. COLLINS, AND MARGARET D. FOSTER. Ind. Eng. Chem., 15: 10, 1078, Oct., 1923. Rapid turbidimetric estimation of calcium and sulfate in water described, using, respectively, acid potassium-oxalate and acid barium-chloride. Reliability of total hardness as determined by soap method (A. P. H. A. Standard Methods) is shown by comparison with that calculated from gravimetric determinations of magnesium and calcium. Average difference between calculated and soap-determined, for 174 samples, is 8 per cent of calculated. Soap results tend to be low for hardness less than 50 p.p.m. Methods for calcium and sulfate follow. *Sulfate.* Prepare standards to contain 5 to 35 p.p.m. SO_4. Place 10 cc. portions of standards and 10 cc. sample of water in test tubes (100 x 10 mm.). To each tube add 1 cc. reagent (100 gms. $BaCl_2.2H_2O$ + 48 cc. HCl, Sp. G. 1.19, in 1 liter dist. water). Shake all tubes vigorously and compare turbidities. Samples containing more than 35 p.p.m. SO_4 should be suitably diluted. *Calcium.* Prepare standards from 4 to 24 p.p.m. Ca^{++}. Place 10 cc. portions of standards and water sample in test tubes. To each add 1 cc. acetic acid (equal vols. 99 per cent acid and water). Shake thoroughly. Add 1 cc. potassium-oxalate solution (20 gms. $K_2C_2O_4$ in 100 cc. water). Shake thoroughly again. After 10 minutes, turbidities may be compared. Relative turbidities are fairly constant for 3 or 4 hours. Dilute suitably when more than 24 p.p.m. Ca^{++} present. *Accuracy of Methods.* 77 samples examined for $SO^{=}_4$ varied from gravimetric results by only 2.5 p.p.m. $SO^{=}_4$ where 10 cc. sample could be used. 0.5 cc. samples, containing from 350 to 750 p.p.m. $SO^{=}_4$, diluted to 10 cc., gave 50 p.p.m. error. 68 samples examined for Ca^{++}, where 10 cc. sample could be used gave average error of 2.2. p.p.m. Above methods are only applicable as preliminary or field determinations, and are not intended to replace gravimetric analysis.—*Linn H. Enslow.*

Determination of Dissolved Oxygen in Presence of Iron Salts. A. M. Buswell and W. W. Gallaher. Ind. Eng. Chem., 15: 11, 1186, November, 1923. Winkler method, as modified by Rideal and Stewart, and adopted by A. P. H. A. as Standard, is dependent upon oxidation of a manganous salt in alkaline medium by dissolved oxygen present. Upon acidification, the manganic compound is again reduced and liberates free iodine quantitatively. Ferric iron will, if present, also liberate free iodine in acid solution. Theoretically, each p.p.m. Fe would make the result for oxygen 0.14 p.p.m. too high; but, in practice, error is found to vary between 0.10 and 0.13 p.p.m., thereby invalidating the method when much iron is present. Mohr's method depends upon oxidation of ferrous iron by dissolved oxygen in alkaline medium. In presence of iron, the Levy modification of this method, as improved by Letts and Blake, gave accurate results; whereas the modified Winkler method did not. Valuable review of the literature is given, and bibliography of 21 titles is appended. —*Linn H. Enslow.*

NEW PUBLICATIONS

New 72 page catalog, issued by the De Laval Steam Turbine Co., Trenton, N. J., exhibits the marked development which has occurred in the improvement of centrifugal pumps, as well as in the direction of larger size and wider use.

"Efficiency Tests of DeLaval Motor Driven Pumps," pamphlet issued by the De Laval Steam Turbine Co., Trenton, N. J., publishes the results of efficiency tests upon several large units installed in municipal water works plants. In sizes ranging from 300 to 1500 h.p. each, these units show overall efficiencies, including pump and motor, between 75 and 82.5 per cent. A 20,000,000 Imp. gal. per day pump at Toronto showed an efficiency of 87.2 per cent, and another pump of about the same size at Baltimore is credited with 86.9 per cent, while a 12 in. pump at Newton, Mass., designed to deliver 2,000,000 gal. per day, showed an efficiency of 83.8 per cent.

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THE ALLOCATION OF WATER SUPPLIES DERIVED FROM THE WATERSHEDS OF INTERSTATE STREAMS[1]

BY LEONARD P. WOOD[2]

The problems growing out of conflicting state rights in interstate streams are not new. In one form or another they have been appearing in our eastern states for one hundred and forty years. The emphasis has changed from questions of jurisdiction and police to fisheries and navigation, including log running and rafting, to water power and water supply for canals, and more recently, to municipal water supply and its twin problem, the disposal of sewage and industrial wastes, with water power again assuming importance. In the arid regions of the West, these problems arose later and have developed much more rapidly, and from the first the emphasis has been on irrigation. This paper will be limited to those phases of the problem connected with municipal water supplies, incidental reference only being made to such of the other phases as are inextricably bound up with the development of municipal water supplies from the watersheds of interstate streams.

As indicating the nature of the problems arising in the development, for municipal water supplies, of the watersheds of interstate streams, some of the larger projects in four of the Atlantic states, Massachusetts, New Jersey, Pennsylvania and New York, will be

[1] To be presented before the New York Convention, May, 1924.

[2] Assistant Engineer, Board of Water Supply, New York, N. Y.

briefly considered. These are all well-watered states with abundant rainfall and good reservoir sites, and with their largest water-consuming metropolitan areas near the mouths of some of their largest streams; yet, because of the fortuitous proximity to these metropolitan areas of purely arbitrary state boundaries, these problems have arisen on a large scale in all. These states are discussed in the order named:

The Metropolitan Water District of Massachusetts, created in 1895, consisting of the municipalities within a ten mile radius centering on Boston, embraced for water supply purposes in 1920 a population of about 1,200,000, nearly one-third of the population of the entire Commonwealth, and used 127 m.g.d. from the Metropolitan District water system. The 1970 population and consumption are estimated at about 2,600,000 and 380 m.g.d. respectively. Considering cost, quality of water, consequences of diversion, and reservations which must be made for communities in other parts of the state, the Metropolitan District has already absorbed all sources of water supply available from watersheds wholly within the state. In fact, the waters of the Nashua river or Wachusett system, representing two-thirds of the capacity of the present works, flow for about 15 miles through the neighboring state of New Hampshire, en route to the lower Merrimac river in Massachusetts. No interstate difficulty arose in this case, a satisfactory financial settlement having been made with the mill owners and with the city of Nashua, the only community in New Hampshire adversely affected by the diversion. For a diversion made at about the same time, the City of Worcester, Mass., also effected settlement without interstate complications, with a large number of mill owners in Rhode Island, the diversion, however, being from but 1 per cent of the drainage area of the Blackstone river where that stream enters the lower state.

All important future additions to the supply of the Metropolitan District must be drawn from the watersheds of interstate streams, or from sources wholly outside the state. The comprehensive plan developed in 1893 to 1895 by the late Frederic P. Stearns, then Chief Engineer of the Massachusetts State Board of Health, and the modified plan submitted in 1922 by the Joint Board relative to Water Supply Needs and Resources of the Commonwealth, X. H. Goodnough, Chief Engineer, both contemplate drawing all future additions to the supply of the Metropolitan District from tributaries

of the Connecticut, a river the lower 65 miles of whose course lie in the neighboring state of Connecticut. No water supplies are now or are likely to be drawn from the main river in Connecticut, the principal adverse interest being water power. The unusual method of development now proposed, limiting diversion to flood flows in excess of 1.2 second feet per square mile, would seem to eliminate any possible grounds for protest by Connecticut against the proposed diversions in and by Massachusetts. Should these projects ever be carried out in their entirety, however, an important part of the problem of sanitary control would lie on the upper parts of the tributary watersheds in the states of New Hampshire and Vermont.

The metropolitan area of New Jersey embraces approximately six counties in the north-easterly part of the state, with a 1920 population of about 2,100,000, two-thirds of the population of the state, and a total water consumption exceeding 280 m.g.d. The 1970 population and consumption in the metropolitan area have been estimated by Allen Hazen at 5,600,000 and 880 m.g.d. respectively. In his admirable report[3] on the water resources of this state and their development for the supply of this metropolitan area, Mr. Hazen well says, "The water resources of New Jersey are great and conveniently situated. Taking everything into account, there is scarcely a state in the Union so favorably situated for providing the water supply of a great Metropolitan District. In saying this we have in mind the quality and accessibility of the water that can be provided; clean and soft for domestic and industrial uses, and near at hand and high enough to be delivered by gravity, or mainly by gravity, in large volumes at relatively low coasts." New Jersey is also fortunate in that one of its largest watersheds, that of the Passaic, drains to the sea through the heart of its metropolitan area, and another, that of the Raritan, along the southern margin of this area. The immediate water-supply situation in the metropolitan area is acute and numerous studies for additional supplies, in addition to those of Mr. Hazen, have recently been made. So ample are New Jersey's water resources that Mr. Hazen was able to point out sources within the state capable of development to yield more than three times the probable 1970 demand of the metropolitan area, without encroaching upon the resources necessarily to

[3] Report on Water Resources of the State and Their Development, Hazen, Whipple and Fuller, 1922.

be reserved for other parts of the state. On closer view, however, it appears that 20 per cent of this prospective supply is from tributaries of the Delaware, and 30 per cent more is to be drawn from the main stream "in the winters of dry years"; and of the new water available by gravity from watersheds wholly within the state, five-sevenths is from tributaries of the Delaware. Since the Delaware below the proposed points of diversion furnishes two-thirds of Philadelphia's present water supply, the entire water supply of other cities and towns in Pennsylvania and much of the supply of the Delaware division of the Pennsylvania canals, the interest, in any such development, of the Commonwealth of Pennsylvania, as a joint claimant to the waters of this boundary stream, is obvious.

But there are other interstate complications in the development of New Jersey's waters. The Hackensack river watershed now supplies about 30 m.g.d. and is being developed to supply about 41. As Mr. Hazen has pointed out, it can be developed up to 65 or 70 m.g.d., but only with part of the necessary storage in New York, in which state the upper half of the drainage area lies. Again, the Wanaque river watershed of 96 square miles, which is now being developed by the North Jersey District Water Supply Commission, has an important part of its watershed and about 8 miles of the shore of Greenwood lake in New York. Since the shores of this lake have a large and growing summer population of campers and cottagers, drawn by the opportunities for boating, bathing, etc., a large part of the sanitary problem of the Wanaque watershed is in the neighboring state. The Ramapo river watershed, recently studied for the City of Bayonne by Weston and Sampson, presents another interstate problem. Three-fourths of the more than 140 square miles of available drainage area, most of the villages including the only village sewered, most of the private sewers, and the only adequate reservoir site being in New York, which also has pressing water supply needs close at hand. Whereas the complete development, including a reservoir in each state, will yield 100 m.g.d. net for water supply, after allowing for necessary compensation water, storage can be developed within the state of New Jersey only sufficient to yield about 40 m.g.d. net. New York, on the other hand, having an opportunity to develop almost unlimited reservoir capacity, should it disregard New Jersey's needs, could develop for its own use something like 80 m.g.d. net, after the same allowance of compensation water. Because of the excellent character of the water,

much softer than that from more distant western sources, and because of its nearness to the centers of consumption in both states and the consequent low cost of development, failure to develop the Ramapo fully would be an economic waste; but full development by and for New Jersey appears to be impossible without some form of effective interstate coöperation.

Philadelphia had in 1920 a population of 1,824,000 and the municipal works supplied 310 m.g.d. The 1970 population and consumption have been estimated,[4] respectively, at 3,500,000 and 500 m.g.d., or 600 m.g.d., if general metering is not effected. Additional supplies for Philadelphia have been the subject of a long series of investigations by able engineers and engineering boards. Consideration has been given to many projects, some involving more than 100 miles of aqueduct through mountain country. The Mullica river in southern New Jersey, with or without contiguous streams, has been repeatedly pointed out as furnishing a large supply of excellent water within 30 to 40 miles of the city at a reasonable cost, but this project has always been dismissed as impracticable on account of the difficulties, probability of long delay and uncertainty of eventual success, in securing permissive legislation by the neighbor state.

The present supply of Philadelphia is all pumped from the Delaware river or from the Schuylkill, a tributary of the Delaware flowing through the city; two-thirds of the supply is taken from the tidal Delaware at Torresdale within the city limits and below the falls at Trenton. Though the water is filtered, increasing pollution of the river will eventually require removal of this intake to some point above Trenton, where there will be competing demands, in New Jersey, for the municipal supply of Trenton, for the supply of the Delaware and Raritan canal, and for water power.

Of the 1920 population of the State of New York, 59 per cent or more than 6,000,000 people were crowded into a small metropolitan area occupying a spur of land projecting from the extreme southeast corner of the state, between New Jersey and Connecticut. New York City alone had a population of 5,620,000 and a water consumption of 735 m.g.d. The estimated 1970 population and consumption of those parts of this metropolitan area which lack

[4] Report on Extensions and Improvements of the Present Water Works System (of Philadelphia) by J. W Ledoux, George W. Fuller, Joseph F. Hasskarl, J. Waldo Smith, September 15, 1920.

adequate local sources of water supply, exceed 13,000,000 persons and 2300 m.g.d. Until within the last twenty-five years, state boundaries presented no very serious obstacle to the development of the water supply for this metropolitan area, the main supply, supplemented by local sources, having been obtained from Long Island on the east and from the Bronx and Croton watersheds on the north, about as conveniently and as economically as it could have been obtained from interstate streams. With a single minor exception, to be mentioned later, the entire supply was obtained from watersheds wholly within the state, although many projects, dating back at least as far as 1823, had been brought forward for taking water from streams in or flowing into the two adjoining states. In the earlier discussions, it does not appear that the questions of interstate water rights were seriously raised.

About 1896, plans were discussed for supplying a part of New York City from those parts of the Ramapo and Wanaque river watersheds lying in New York State just north of New Jersey, into which state these streams flow. Interference with existing and prospective water supply developments in New Jersey and the probable adverse action of that state, were among the strongest arguments against this project. In 1900, John R. Freeman, in his classic report on New York's Water Supply strongly recommended the immediate development for New York City of the Ten Mile river and the upper Housatonic, the Ten Mile which lies in New York State, draining into the Housatonic, which is a Connecticut stream. The project was most attractive. The need for more water was urgent and on the Ten Mile an immediate supply of 150 m.g.d. could be developed by works wholly within the state, and 105 m.g.d. of this could be delivered to the city with no cost or delay for aqueduct construction, by utilizing the surplus capacity of the two Croton aqueducts above the then developed safe yield of the Croton watershed. From the Ten Mile and the upper Housatonic together, Mr. Freeman estimated that 750 m.g.d. could be delivered to the city by gravity at an elevation 300 feet above sea-level. There were no adverse water supply interests in Connecticut and only a moderate amount of water power would suffer by the diversion. Barred from the Ten Mile-Housatonic by unfavorable legal opinion, especially by the fear that adverse legal action by Connecticut might cause fatal delays, the city, after six more years of deliberation, proceeded with the construction of the Catskill

system which is now approaching completion, going for its water two and one-half times as far as to the Ten Mile-Housatonic.

In 1903 to 1905 the water supply situation in Richmond Borough of New York City was acute, the supply being inadequate in quantity and very poor in quality. The island borough of Richmond while politically a part of New York City and State is geographically a part of New Jersey, and its shores are washed by the waters of two of New Jersey's largest rivers, the Passaic and the Raritan. A New Jersey corporation wished to furnish, and New York wished to buy, at least a temporary supply of 3 to 10 m.g.d. to tide over the interval pending completion of the Catskill works. The proposed diversion was about 0.1 to 0.4 per cent of the quantity which Mr. Hazen has since shown to be available for this part of New Jersey, and from a watershed of which 141 square miles or 18 per cent was in New York. In 1905 New Jersey enacted legislation prohibiting the transportation of any of the fresh surface waters of the state "into any other State, for use therein." In consequence Richmond borough endured for twelve years longer an inadequate and inferior supply and now gets its water from the Catskill mountains 120 miles or five times as far away.

New York State now again finds it necessary to seek large new supplies for its metropolitan area. While this state has been particularly fortunate in being able to develop its present large supplies on watersheds wholly within its own boundaries, it cannot continue to do so indefinitely. On the north, east, south and west its waters drain into adjoining states or into international streams. With thousands of square miles of the watersheds of interstate streams within its own boundaries it will find it difficult to supply its own cities unless some effective interstate coöperation can be had.

While the preceding examples are all projects of unusual magnitude, the problems under discussion arise also in the development of small municipal and private water supply works. These smaller projects, however, frequently involve such minor encroachments upon the riparian rights of citizens of the neighbor state as to escape the notice of jealous state officials and legislatures, and to admit of settlement by ordinary judicial process or by agreement, without raising troublesome questions touching the dignity, sovereignty and supposed vital interests of a state.

The preceding examples show some of the difficulties of the present situation, fundamentally the lack of any system of allocation as

between states. Lacking allocation and such interstate or superstate authority and control as will make allocation both possible and effective, the water supply engineer and his client, contemplating a diversion even within their own state, from an interstate watershed, are left in a fog of uncertainty and doubt. If proposing a diversion in an upper state, what costs and delays will have to be met before the proposed diversion can become effective, and how much if anything will they ultimately be permitted to divert? If proposing a development in a lower state can they rely upon the undiminished flow from the upper state, or will they at some time find themselves, even temporarily, deprived of water; and what, if any, coöperation in enforcing sanitary protection will they have in the upper state? If one of the contiguous states proposes to divert from the boundary stream, there is added to all of the above the further question: What protection will they have in their proprietorship in waters released into the channel above the point of diversion from storage built by and in the diverting state? And should economic development and effective utilization require the acquisition of property, the flooding of lands or the construction of works in another state, there are added to all the other difficulties the lack of power of condemnation, the possibility of excessive and discriminatory taxation, and existing or possible prohibitory legislation in the other state.

Three general lines of action, other than the negative one of shunning interstate waters at all costs, as exemplified in the recent history of New York, are now available:

1. To take what is wanted regardless of the interests of lower states and hope to get away with it.

2. To take what is deemed reasonable and just, to endeavor to reach amicable settlement with all lower interests, and hope the judgment and action will be sustained by the courts.

3. To endeavor to secure an allocation in advance.

The first two place ultimate reliance upon possession and upon a successful defense in the courts, to confirm the appropriators in the enjoyment of that which they have taken. The first has had its most perfect development in irrigation work in the West, and is the only line of action which, so far as writer knows, has lead to a definite allocation by the court of last resort, of the waters of an interstate stream (Wyoming v. Colorado, 259 U. S. 496; 260 U. S. 1). The second has succeeded in two of the Massachusetts cases cited,

and is hopeful where the diversion is small or limited to flood flows, where there is no conflicting water supply demand in the other state, where injuries are susceptible of pecuniary compensation, where the diverting authority is prepared to deal generously with lower riparian owners, and where breadth of view and a desire for harmony, rather than prejudice, suspicion and jealousy and the exigencies of local politics, determine the attitude of officials of the interested states. Both lines of action are, however, under the shadow of probable or possible costly litigation and vexatious delays, of an eventual judicial limitation of the diversion, and possibly even a sustained injunction which would prevent utilization of the works.

In following either of the first two methods the engineer has no body of federal or interstate law to guide him. Under the Federal Constitution the power of the United States over the waters of an interstate stream is limited to the preservation and improvement of navigation. The decisions of the United States Supreme Court are, however, gradually building up a body of what is in effect interstate law. Unfortunately the decisions pertinent to our problem are few, and not in all respects consistent. The cases dealing directly with the diversion of interstate waters are as follows, in the order of date:

New York v. Pine (185 U. S. 93), 1902

Suit to enjoin a diversion for municipal water supply, the works for which were far advanced in construction Action of a lower court granting an injunction reversed, not on the merits as a controversy over interstate waters, but on the grounds of delay on the part of the plaintiff and other considerations.

Missouri v. Illinois (180 U. S. 208; 200 U. S. 496), 1906

Suit to enjoin pollution by discharge of sewage of a community outside the watershed, the Sanitary District of Chicago. Dismissed, without prejudice, on the grounds, apparently, of failure to prove any injury, and especially, failure to prove that such pollution as there might be was not due at least in part, to sewage discharged within the plaintiff state.

Kansas v. Colorado (185 U. S. 125; 206 U. S. 46), 1907

Suit to enjoin a diversion long practiced by and under the authority of Colorado, as well as proposed additional diversions. Dismissed, without prejudice, on the grounds that, while the injury to Kansas was real, "regarding the interests of both States and the right of each to receive benefit through irrigation and in any other manner from the waters of this stream, we are not

satisfied that Kansas has made out a case entitling it to a decree. At the same time it is obvious that if the depletion of the waters of the river by Colorado continues to increase there will come a time when Kansas may justly say that there is no longer an equitable division of benefits and may rightfully call for relief against the action of Colorado, its corporations and citizens in appropriating the waters of the Arkansas for irrigation purposes."

Hudson County Water Co. v. McCarter (209 U. S. 349), 1908

To review decrees of the lower (New Jersey) courts enjoining diversion of water from Passaic river for sale to the City of New York in violation of a New Jersey statute prohibiting the transportation of the fresh surface waters of the state "into any other State, for use therein." The constitutity of theional New Jersey law was upheld.

Wyoming v. Colorado (259 U. S. 496; 260 U. S. 1), 1922

Suit to prevent a proposed diversion under the authority of Colorado. Decree enjoined the defendants from diverting more than 15,500 acre-feet per year by means of the Laramie-Poudre project, determined the "fairly constant and dependable flow" realizable "by means of practicable storage and conservation," and apportioned the whole of this reasonable flow between the two states, on the basis of priority of appropriation. This was a question between states, dependent upon irrigation, and both of which recognized the doctrine of prior appropriation, not the common law of riparian rights which prevails generally in the East.

Reasonable limits of space preclude a fuller discussion of these and of other pertinent decisions of the United States Supreme Court and of other courts. At least those so briefly cited will well repay the study of any engineer contemplating a water supply diversion from the watershed of an interstate stream.

The third line of action, that of endeavoring to secure an allocation in advance, is the only one which can place a water supply project involving an interstate stream on a thoroughly sound foundation in advance of construction and use, as it is also the one which best promises to solve the problems of acquisition of property, flowage of lands and operation of works in another state. Within their own boundaries and as between their own citizens many states have long since recognized this principle by the creation of water supply or conservation commissions, empowered and directed to make such allocations.

Allocation as between states or the citizens or corporate creatures of different states implies some authority superior to any single state. Such authority might reside in an interstate treaty respecting a particular case, in a continuing interstate commission deriving its authority from a treaty, or in the federal government. A treaty,

negotiated by commissioners appointed by the interested states and ratified by the legislatures of those states and by the Congress, is binding, but tends to be inflexible, although provisions for future modifications and review can be incorporated in the compact. In efforts toward this solution the states of the semi-arid West have lead, seven examples of treaties now in various stages of negotiation, for the allocation of water primarily for irrigation, having been recently noted in the engineering press;[5] and the Colorado River Compact, the pioneer and the most ambitious of these treaties has since been ratified by six of the seven interested states. In the East a joint commission to study the most effective utilization of the waters of the Delaware has been authorized by the legislatures of New York, New Jersey and Pennsylvania, and commissioners have been appointed by these states. It is suggestive that one state has appointed its Commissioner of Health, its Secretary of Forests and Waters and its Deputy Attorney General.

A continuing interstate commission offers many advantages. It could exercise the necessary control to insure that the terms of each allocation were fulfilled, could provide the flexibility requisite to meet changing needs, should be able to solve problems of interstate sanitary control as they arise, would, by the fact of its continuity, maintain a constant touch and familiarity with the interstate water problems of its field, and, not least important, would avoid the very serious delays incident to creating new machinery whenever the need for a new allocation arose.

The principles which should govern the allocation of waters would appear to be these: The public ownership of flowing waters whether above or under ground; administration of these waters on a regional, if not a national, scale, such regions transcending not only state lines but divides as well; beneficial use as "the measure, the limit, and the basis of the right;"[6] an established order of preference as to class of use, which order, except for domestic and municipal water supply, will vary with changing conditions of time and place; the better right within each preference class of use determined by priority in time of perfected use; limitation of allocations with due regard to economy and efficiency of use; compensation for reduction or cancellation of an allocation or of a prior grant or prescriptive right to be based on reduction in amount of water in actual and

[5]Engineering News-Record, September 27, 1923, p. 505.

[6]Some Principles Relating to the Administration of Streams, Clarence T. Johnston, Trans. Am. Soc. C. E., 1915, p. 630, and discussions.

habitual efficient use, interpreting "efficient" in the light of the state of the art concerned at the time of deprivation, with no compensation for deprivation of water wasted by non-use or inefficient use; abandonment to the public of rights of use not promptly utilized in the manner specified in the grant, except that, subject to approval of the administrative authority, rights of sale of a temporary surplus, to help carry charges on costly works by which it has been made available, should be secured; and maximum economy of development for all uses, on the regional scale. A discussion, before the American Society of Civil Engineers, of the administration of streams,[6] by Clarence T. Johnston and others, is highly illuminating and suggestive, and develops many of the principles here outlined. As to order of preference in use, domestic and municipal water supply will doubtless always be recognized as the highest use. The relative order of other classes of use, disposal of sewage and industrial wastes, irrigation, navigation, water power, supplies of industrial and process water, fisheries, and aesthetic and recreational use, must vary with progress in the arts concerned and with predominant local needs, that is with time and place.

In any current project of large magnitude it is the writer's feeling that an interstate commission to examine the situation, formulate a policy and recommend an allocation, such allocation to be embodied in a treaty between the states, offers the line of least resistance and greatest present promise. This is, however, merely an expedient and does not reach the heart of the problem. The very serious loss of time which this procedure involves, and the chance of an unsympathetic response by some of the states invited to participate might be overcome, with respect to future questions arising among the same states, by some continuing interstate commission empowered to make binding allocations; and only by some form of continuing administrative authority can application of the principles outlined be even approximately realized, either pending or after the revision of our water laws. The practical working out of the problems of allocation by this method is so new that much effort and study will be required to establish the principles and to evolve the best mechanism and procedure. It is hoped that this paper may promote discussion which will crystallize the problem and perfect this or some better method of attack.

In closing, the writer wishes to acknowledge his indebtedness, for many valuable criticisms and suggestions, to Mr. J. Waldo Smith at whose instance this paper was written.

THE CLEANING OF CAST IRON WATER PIPE LINES

By Charles Haydock[1]

Cast iron pipe comprises the greatest length of all pipe lines laid to convey water. It is unquestionably true that, under normal conditions, a cast iron pipe line is relatively permanent, but this does not cover the entire situation, as it neglects the function of the pipe line, which is to convey water. If the capacity of the pipe line is reduced, the value of the pipe line is impaired to an equal extent, even though there has been practically no loss of metal from the pipe line coincident with the reduction in capacity.

Many of the water supplies of Eastern United States are of a desirable type, that is, they are soft and low in total solids and alkalinity. Unfortunately these desirable waters may also be classified as "active waters," in that they actively corrode pipe lines. For this reason the loss in capacity of pipe lines due to tuberculation is, in general, a more serious item in Eastern United States than in other sections of the country. Wherever the coating is imperfect or punctured, even if only to the extent of a pin hole, a tubercle forms which continues to grow indefinitely. A comparatively small amount of tuberculation is sufficient to cause a serious loss in capacity, due, no doubt, to the eddy currents set up by the roughened interior. The reduction in area by tuberculation is not usually material, unless the line is quite old or the water very active.

The expansion of our water works systems has been so rapid in recent years that the average age of the pipe lines is not yet very great. As this increases, the seriousness of loss of capacity due to tuberculation will increase.

Loss in capacity is not always due to corrosion or tuberculation, but this is by far the commonest cause throughout the soft water area of eastern United States. In order to prevent such losses, two lines of action are open, treatment of the water and of the pipe.

Concerning the quality of the water, it has been stated that these active waters are of a most desirable type, and in general, it is

[1] Engineer, Water Companies, Philadelphia, Pa.

difficult to secure public approval of any method of treatment which would reduce the activity of the water at the expense of its softness. In many cases this is probably poor economy, as the active waters attack plumbing and service lines, etc., with such vigor as to constitute a greater annual expense per capita than would be required to reduce the activity, while the slight increase in hardness which might occur, as a result of reducing the activity, would scarcely be noticeable in many cases.

Very gratifying results have been secured by improving the quality of metals and in using alloy metals for many purposes in various industries in an effort to reduce corrosion. Application of such principles to the cast iron pipe industry might increase the cost of pipe over the cost of that now used, but if the carrying capacity of the pipe line could be mintained, it is believed that private water companies and progressive municipalities would be willing to pay the additional cost for the greater value secured. The only recent development of importance in the pipe industry is in the use of the centrifugal or de Lavaud process of casting pipe, which has been described before the Association at the Philadelphia Convention in 1922. Pipe manufactured by this process has not yet been in use long enough to demonstrate whether its carrying capacity is any more permanent than sand-cast pipe, but considering the methods of casting and the fact that a better grade iron is used, it should produce a pipe more resistant to tuberculation and corrosion.

Another method which suggests itself is improving the character of the coating. The writer does not believe that this holds as much promise as improvement in the pipe, for any impairment of the coating, whether due to abrasion, such as frequently occurs in shipping and handling, air bubbles or any other cause, opens an avenue of attack upon the metal. Recently a considerable tonnage of cast iron pipe has been coated with high grade asphaltic enamels, such as have been used very successfully on ship bottoms, and in similar locations exposed to unusually difficult conditions. This coating is much thicker and adds materially to the cost. The increased cost can no doubt be reduced if there is sufficient demand for this greater protection to warrant installation of the necessary facilities for handling. It has been suggested that it might be possible to develop a cheap process of porcelain lining for cast iron pipe which could be used to carry very active waters, but so far as the writer knows, no serious consideration has been given to this,

as it will readily be appreciated that it will require a very tough porcelain to be suitable for such purposes, while the difficulty of tapping and cutting mains would be greatly increased.

Loss in capacity may also be due to air binding at summits, sediment at low points, precipitation from softened water, dropped gates of valves and foreign matter in the line. Many curious things have been removed from pipe lines during cleaning operations, including picks, shovels, axes, lumber, caulking tools, dinner buckets, overalls, stones, etc.

The purpose of this paper is to discuss only the losses due to corrosion and tuberculation, and results obtained by cleaning such lines. The benefits of cleaning are usually greatest where fuel costs are highest or capacity limited, or both, which generally occurs on long mains between sources of supply and centers of distribution.

Pipe cleaning is not a new process and has probably been practiced as long as pipes have been used to convey liquids. Probably the first large scale cleaning operations were in cleaning oil lines, some of which lose capacity quite rapidly, due to the deposition of paraffin. This deposit is quite soft and can readily be removed by passing a cleaner, similar to a boiler tube cleaner, through the pipe line, using the oil pressure as the driving force. Water mains may be cleaned in the same manner, but it is a much more difficult process, as the deposit is harder, the pipe lines generally larger, the length of time for which the line can be removed from service for the cleaning operation is usually less and the pressures are in general lower. If the normal pressure is insufficient to force the cleaner through the line, it can be pulled through by a cable and winch, but this is usually impractical in long lines of large diameter. It is also possible to install a temporary pump to raise the pressure to force the cleaner through the line. If a high pressure system is available nearby, a temporary connection may sometimes be arranged and the required pressure secured in that way.

Cleaning is not a remedy in all cases of reduced capacity of pipe lines, but it is of decided advantage in many instances, and it is here desired to call attention to certain definite cases in which very gratifying results have been obtained. The writer's experience indicates that the effects of cleaning are not permanent and careful consideration of the facts will indicate that this is logical. The length of time during which the benefits persist varies, depending chiefly on the same factors that influenced the original loss in capac-

ity, namely, the character of the metal and the nature and condition of the coating. A cleaning operation, vigorous enough to dislodge tubercles, will also injure the coating to some extent, and this opens an avenue for more rapid corrosion after cleaning than before, as no method has yet been devised to recoat the interior of a pipe line underground. This, however, is not a valid objection to pipe cleaning, for, where cleaning is needed, the cost of same is usually reasonable. In most cases, the company could well afford to clean the pipe line at intervals of the life of the benefits of the cleaning rather than to lay new pipe lines or build booster pumping stations to increase capacity or pressure, or both.

The attention of the Association has previously been called to the conditions at Charleston, S. C., where the effects of pipe cleaning have disappeared within a few months, due to the great activity of the water. Fortunately, this is an unusual condition. The cost of pipe cleaning is certainly not warranted in such cases, and the solution adopted of coating the interior of the pipe with cement seems to be more practical.

If the capacity of a long line appears to be decreasing or the pumping head increasing, the actual carrying capacity should be determined. If this is materially less than the theoretical capacity, a careful investigation should be made to determine the cause. A survey and determination of the hydraulic grade line is usually worth the cost, and will disclose any unusual conditions. If it is possible to shut down the line, static pressure or a siphon test will show how tight it is and a recording meter will complete the record. If there is no meter available, a pitot test can be made at a reasonable cost. The presence of consumers' taps and branch connections increases the difficulty of cleaning a line. After a pipe line has been cleaned, it is sometimes necessary to pump out the consumers' taps attached to same by means of a force pump for the reason that the particles dislodged in the interior of a pipe line may be forced into the corporation cocks. Branch connections and valves are sources of possible difficulty in cleaning a line by reason of the possibility of the cleaner sticking at such points. Having all this information available, it is usually possible to forecast the probable benefits of cleaning.

The writer's first experience in pipe cleaning was gained when two parallel lines from a reservoir to a railroad yard were cleaned. This line was particularly difficult as it contains many bends and is of

various sizes, the exact location of the reducers being then unknown. Some of this pipe was laid in the fifties and sections removed indicated that it was uncoated pipe, cast on the side in 9 foot lengths. Before this line was cleaned, it carried a little more than half the theoretical capacity, while, after cleaning, this was increased to nearly 90 per cent. The other line from the same reservoir was twenty or thirty years old and is the usual 12 foot coated pipe. Its capacity was increased from two-thirds to more than 90 per cent of that of new pipe. Such results are most encouraging. The unfortunate feature is that the results were not permanent and, about five years later, the capacity had decreased to approximately what it had been before cleaning. As the uncoated pipe had no protection at all, it is natural that it should have corroded rapidly following cleaning. This is an unusual condition, which, fortunately, is not often encountered.

The capacity of a pipe line approximately 3 miles long, half of which was 10 inch, about thirty years old, the balance 12 inch, twenty years old, was known to be inadequate and on investigation it was determined that this was due not only to tuberculation 1 inch thick in the 10 inch portion, causing a material reduction in area, but also to serious leakage in two creek crossings which did not show on the ground. In cleaning the 10 inch line, a joint missed at the first pouring was encountered. The lead in the pipe weighed about 50 pounds and measured 4 feet along the bottom of the pipe. The cleaner picked this up and rolled a portion of it into a ball until the weight was so great as to stop the cleaner under the low water pressure available. As a result of this, it was necessary to cut the line to remove the cleaner. Due to the cleaning and reduction in leakage, the capacity was more than doubled, so that it was nearly equal to that of a new line. All of this increase in capacity can be credited to the job, as the leakage would not have been found unless cleaning had been done. A further result of this cleaning was that it was possible to discontinue the operation of a pumping station which was originally installed as an emergency or stand-by unit, but due to the decreased capacity of the line, it was necessary to operate the station continuously for some time.

Another line cleaned was approximately 5 miles long. The available head was so low that there was not sufficient pressure to force the cleaner through the line. Rather than pull it through by means of a winch, a temporary boiler and pump were set up and water

pumped into the line at a pressure sufficient to move the cleaner. In this way, the line was successfully cleaned and the capacity was greatly increased. As in the last case, this increase in capacity was sufficient to enable the discontinuance of a pumping station, which had originally been installed as an emergency unit, but had become practically a permanent installation by reason of the decreased capacity of the gravity line. The blow-off valves and automatic air vents on this pipe line had not been properly maintained, and were therefore not functioning. It was found that there was a considerable accumulation of sediment at the low points and that the capacity of the line was further reduced by air binding at the summits. Here again, while all of the increase in capacity was not due to the passage of the cleaner through the line, it is believed that all of the benefits are properly to be credited to the cleaning operation, for, if this had not been undertaken, the other difficulties would not have been located and it would have been necessary to continue the operation of the pumping station.

At another point, the discharge from a pumping station to a reservoir, consisting of parallel lines of 12 inch and 16 inch pipe, approximately fifteen years old, was investigated, and it was decided to clean both lines, starting with the 12 inch. After this was done, it was found that the 12 inch was carrying a much larger percentage of the flow and that the capacity had been increased approximately 30 per cent. These figures indicated that the cost of cleaning the 16 inch pipe line was unwarranted, as the reduction in pumping head which could have been accomplished by pumping through a clean line would not have decreased the fuel bill sufficiently to warrant the cost. The performance of this system is being observed and the 16 inch line will be cleaned as soon as capacity becomes a controlling feature or the possibilities of fuel saving become attractive. This line contained comparatively few tubercles, some of which were quite large, reaching a diameter of 1 inch and a height of $\frac{5}{8}$ inch. At one point in the line the cleaner was stopped by a small stone wedging between the cleaner and the seat ring. Upon removing the bonnet, it was possible to pry the cleaner loose and the stone was removed. At another point a "missed" joint was encountered, the lead having spread out to a length of approximately 4 feet and contained almost sufficient lead to run two joints. The water carried in this line is filtered. The total solids are always quite low and the alkalinity of the raw water seldom exceeds 12 to 15 parts per million,

while in the spring it becomes very low. This water is of the type first mentioned in that, while it is of a very desirable quality as to its total solid content, it is also very active and attacks the pipe line quite rapidly.

Another job consisted of cleaning 4 miles of 12 inch line, approximately twenty years old, the frictional loss through which before cleaning was nearly three times that of new pipe, and after cleaning, approximately the same as that of new line. The capacity was increased by approximately 35 per cent and the delivery pressure by 20 pounds under normal operating conditions. It would have been possible to obtain a greater increase in capacity by delivering at the same pressure, but the increase in pressure was a very desirable feature under the operating conditions. In cleaning this line, an axe complete with handle was recovered, also an iron wedge from a gate valve and a number of stones of various sizes, several of which were quite large.

A $10\frac{1}{2}$ mile section of 16 inch pipe line in the same system was also cleaned. As a result of this cleaning it was possible practically to discontinue the operation of a booster pumping station for the delivery without pumping after cleaning was greater than the delivery with pumping before cleaning. The gravity delivery of this line was increased 60 per cent. By reason of the increased flow, the percentage of increase when boosting after cleaning was only 30 per cent. The testing done in connection with this work disclosed the existence of two serious leaks along the pipe line, of which there was no indication on the surface of the ground. The tests also disclosed the existence of a valve of which there was no previous record. This valve was nearly closed, and under maximum delivery caused a material loss of head through the pipe line. The increase in capacity was therefore not due entirely to cleaning of the line, but was also due to the elimination of the leaks and the excessive loss of head.

The capacity of a 4 inch pipe line a mile long supplying a small railroad water station was found to be so reduced that the laying of a new line was contemplated, but by cleaning a capital expenditure was avoided. The loss of head available in this line was so small that it was necessary to pull the cleaner through, at which time it was found that a summit was practically level with the intake, and the low points had material quantities of sediment. The cleaning was done in the winter time when the ground was covered with a foot of snow. The location of this pipe line was not known definitely,

and it was necessary to prospect for same. As a result of this, the cost of the work was at least double what it should have been. The increase of 40 per cent in capacity is sufficient to obviate the necessity of renewing the line for a considerable period in the future.

During the past summer 22 miles of 12 inch trunk line have been cleaned. The cleaned line consisted of three sections, the longest of which is more than 13 miles. The increase in capacity due to cleaning this portion was approximately 35 per cent. The unit length cleaned was governed by the location of a number of 90 degree bends, through which it was not considered advisable to attempt to pass the cleaner. These units ranged in length from $\frac{1}{2}$ to about 4 miles.

The second section of this line, more than 3 miles long, was cleaned with similar gratifying results. In this section the pressure was low, and considerable difficulty was experienced in cleaning on that account. Under certain conditions there was practically no flow previous to cleaning. After cleaning, under similar conditions, the flow was approximately 350,000 gallons per day. The percentage increase in such cases is hardly a fair criterion, but this improved condition is of the greatest value in the operation of the line.

Cleaning the third section of this line, which is more than 6 miles long, and carries ample pressure for cleaning, resulted in an increase in capacity of approximately 46 per cent. The cleaner successfully passed through no less than five 45 degree bends in this section, but did not pass through a sleeve which had been used to make a 15 degree bend. The ends of the pipe had not been properly brought together at this point and a large stone dropped into the space. The cleaner wedged against this and it was necessary to cut the line to remove it.

This pipe line is approximately sixteen years old and carries a high quality water which is quite active, and the tuberculation was sufficient to reduce the diameter of the line in many places. The tuberculation was not evenly distributed along the line as some sections were comparatively free while others, as above noted, showed a reduced diameter. Cleaning this pipe line disclosed the usual number of foreign objects, including many stones, a 6 foot piece of 2 by 4 inch lumber, a complete shovel and a shovel handle. No doubt the shovel itself will be recovered at some later date, probably under a valve or else by obstructing the cleaner. It seems impossible to keep such foreign objects out of a pipe line and, while it is most unfortunate that this is true, it is hardly likely that in the

average case the capacity of a line is materially reduced unless they are collected at a critical point, such as a valve or bend.

These 22 miles of pipe line which were cleaned comprise the critical sections in a 48 mile length of 12 inch line. The benefits derived consist not only in the increased capacity, but an important item was in reducing outside purchases of water. There are comparatively few points along this line where water can be purchased. None of these available waters are equal in quality to the water carried by the line and they are also more corrosive and expensive.

Approximately 3 miles of 10 inch pipe line has been cleaned very recently. The water supply at this point is obtained from a large river which is always quite hard and frequently acid. In order to correct these conditions, the water is treated constantly without sufficient sedimentation capacity. As a result of this, the treated water is not properly settled and precipitation occurs in the pipe line. The water is relatively inactive and there were comparatively few tubercles, but the sediment from the treating plant had formed a coating approximately $\frac{3}{4}$ inch thick throughout the line. This coating was readily removed and was discharged from the blow-offs like molasses. The increase in capacity due to cleaning was 65 per cent, while, under operating conditions, 20 per cent more water is delivered at double the former pressure.

Summarizing the situation, it is apparent from the examples cited that in many cases, pipe cleaning, especially of long transmission mains, will produce very substantial benefits where there is a deficiency in capacity or pressure. All water companies do not have the problem of long transmission mains, but those which do, in many cases, would find it to their advantage to investigate same, as actual conditions may be determined only by observations.

In view of the present high cost of labor and materials, pipe cleaning is particularly attractive as it permits restoring the capacity of a pipe line at a reasonable operating cost and avoids capital expenditures.

ELECTRIC PUMPAGE AT KANSAS CITY, MISSOURI[1]

By Albert L. Maillard[2]

Recently a decision was made as to whether steam turbine or electric motor drive should be adopted in the proposed new high lift pumping station for the additional water supply of Kansas City, Missouri. The electric motor was selected. This action seems, on the surface, to be contrary to the accepted best practice followed for years and in vogue today, under similar conditions. While it is true that Kansas City, Missouri, has a direct pumpage system and is neither adjacent to nor fed by any hydro-electric power system, yet there are local conditions which make electric pumpage indeed very desirable.

Before stating the factors which entered into the final decision it might be well to discuss the nature of the investigations and studies that were made of both the steam and electric stations as to their design, cost and reliability of service.

The scope of the additional water supply works for Kansas City, Missouri, comprises an intake and low lift pumping station, located on the river near North Kansas City, Missouri, a purification works and secondary lift station some two thousand feet away from the river bank in North Kansas City, a main pressure tunnel and two branch pressure tunnels connecting the secondary lift station with the existing high lift station known as Turkey Creek station and the proposed new high lift station in the East Bottoms, Kansas City, Missouri, an equalizing reservoir at the East Bottoms station, and the necessary distributing mains from the new high lift station.

The low and secondary lift pumping stations will be equipped with six 40 m.g.d. pumps each. Four of these pumps will carry the maximum load, while two will be held in reserve. The head at both

[1] Prepared under the direction of the Standardization Council and furnished through Committee No. 3, on Pumping Station Betterments, L. A. Day, Chairman.

[2] Electrical Engineer, Fuller and McClintock, Consulting Engineers, Kansas City, Mo.

of these stations varies widely; that at the low lift chiefly due to changes in river stages while that at the secondary lift due to friction in the tunnels. At each station the range in head is from about 18 to 50 feet. A maximum of about 500 horse power will be necessary to drive each of these pumps. A steam turbine of that capacity is comparatively small and consequently not very efficient. Then the boiler plants required for these two pumping stations would be small. Since they would be independent plants it would be necessary to carry spares in each plant. Besides, it would be very expensive to build a boiler plant at the low lift station, due to the fact that the pump room floor in this station has to be located some 34 feet below the present grade, making the structure a rather expensive one. Increasing its area would add considerably to its cost. At the secondary lift station there are, in addition to six pumps similar to those at the low lift station, several small pumps in connection with the purification works which pumps would be more cheaply and better equipped with electric motor than with steam turbine drive. For the foregoing reasons, it is better to drive all pumps at the low and secondary lift stations electrically.

The high lift station, based on steam turbine drive comprised four 35 m.g.d. units and four 2250 k.w. turbo-alternators for generating the current required at the low and secondary lift stations. The pumping units provided one spare, while the generator units provided two spares. Thus, by concentrating all steam generation at one point the best possible efficiencies are obtainable. The turbines driving the pumps and those driving the generators were to be exact duplicates of each other and of the highest efficiency obtainable. The 35 m.g.d. capacity was selected because it necessitated a turbine of about 3000 horse power at which size very good efficiencies are obtainable. Yet this capacity gave enough flexibility to suit the expected water consumption.

Compared with this combination of steam high lift and power house and electric low and secondary lift stations was the proposition of driving the pumps at all stations electrically with power purchased from one of the public utilities.

The high lift station, when electrically equipped, contemplated six 24 m.g.d. pumps instead of four 35 m.g.d. as in the case of steam turbine drive, due to the fact that greater flexibility could be obtained without sacrificing any efficiency in the electric motor.

Since the low and secondary lift stations would remain unchanged regardless of whether steam or electric drive were adopted at the high lift station, the comparison of costs of the two schemes resolved itself into that of the total operating and fixed charges of a steam pumping station and electric generating plant as against those of an electric pumping station operated with purchased power.

Other considerations which necessarily entered the investigations were those of reliability of service and flexibility of operation.

In regard to the latter it might be said that since centrifugal pumps are under consideration the range of flexibility per unit is rather limited. It is true, however, that the steam turbine with its ability to increase or decrease its speed above or below a certain normal has an advantage over the constant speed motor as well as over the variable speed motor, although not to such a marked degree in the case of the latter.

This advantage can be offset considerably by reducing the size of the electric motor driven units relative to that of the turbine driven pump. To attain this result six 24 m.g.d. pumps were substituted for four 35 m.g.d. units as were considered with steam operation. The motors for the 24 m.g.d. units at 380 feet head are approximately 2000 horse power. Their efficiencies are almost identically equal to those of 3000 horse power rating. In consequence, no loss of efficiency has been suffered while greater flexibility has been gained. It might be well to emphasize this fact, namely, that the existing high lift station known as Turkey Creek Pumping Station is steam operated and is equipped with two turbo-centrifugals, one a 20 m.g.d. and the other a 30 m.g.d., as well as three 20 m.g.d. triple expansion reciprocating engine driven units. These last mentioned carry partial loads efficiently and can be depended upon to take care of the fluctuations in load which range between even multiples of the centrifugal units.

Other considerations which come under the head of flexibility of operation are those of labor and time entailed in starting and stopping turbines with the attendant boiler room adjustments (such as operating of boilers at ratings which will reduce to a minimum banked fires without imposing too severe load conditions on the boilers and yet operate them normally at an economical rating), compared with the ease of starting and stopping motors.

Regarding reliability of service there is no doubt that the steam plant is the more dependable. The question is by how wide a margin.

Kansas City, Missouri, is fortunate in that it is served by one of the most modern and efficient steam power plants in the world. The "Northeast" station of the Kansas City Power and Light Company, located within a mile of the site of the new high lift pumping station in the East Bottoms, serving this pumping station, through underground feeders, directly from its busbars to the busbars of the pumping station, without the intervention of transformers, has in its favor ideal conditions for rendering this service. The contract between the Company and the City provides that the latter will have first call on the entire generating capacity of the Company's power stations. The contract provides, also, for very liberal feeder capacity, connecting the stations by two separate and independent routes. It further provides that the feeder capacity be such that the cables in any one duct line shall be able to carry the entire load of the pumping station in case the other duct line be taken out of service for any period of time. In addition, no other consumer can be fed from these cables. With the taking of these and other precautions, too detailed to be included within the scope of this paper, it is felt that the service will be as reliable as it is possible to obtain with the best equipment and methods in use today. It may not be too optimistic to feel that the service will so closely approach in reliability that of a steam station that there will be little argument for choosing the latter other than that prompted by sentiment.

The comparison of the relative costs of constructing and operating the two types of stations was carefully investigated. Design studies were made of both types of stations. Detailed estimates of costs of construction based on current prices obtained from the various manufacturers were made. From the capital investment thus obtained, fixed charges were determined. In the case of the steam station operating conditions were based on the best modern practice used in medium sized steam central stations. The electric station also was patterned on best modern practice. Costs were grouped under the following headings: Fuel, electric power, labor, lubricants, supplies, maintenance and repairs, interest, depreciation, and transmission line lease.

Load variations with corresponding changes in operating conditions as well as in investment and consequent fixed charges were made every five years. The periods started with the year 1928 and followed on with 1933, 1938, 1943 and 1948. This means of comparing costs showed which type of station would really be best in the end for the City to adopt.

Before the cost of electric power and the transmission line lease could be calculated it was necessary for the City to secure bids for power from the local companies supplying power. In addition to being in competition with each other the companies had to compete with steam operation of the pumping station. These factors resulted in obtaining for the City a very low rate. In consequence the City has entered into a contract with the successful bidder, namely, the Kansas City Power and Light Company, to supply current at the City's pumping stations in the form of three phase, sixty cycles at thirteen thousand two hundred volts and at the following rates:

Demand charge—$1.56¼ per month per kilowatt, plus $3000 per month to cover charges on transmission lines

Energy charge—$0.007 per kilowatt hour until the demand at the high lift station exceeds 2800 kilowatts.
$0.00675 per kilowatt hour until the demand at the high lift station exceeds 4250 kilowatts.
$0.0065 per kilowatt hour until the demand at the high lift station exceeds 5600 kilowatts.
$0.00625 thereafter

These energy rates are subject to a fuel rider which in substance states that, should the cost of fuel to the Company vary from a price of four dollars a ton, the City shall pay an addition on or receive a deduction from the rates depending on whether the price of fuel increases or decreases.

The contract contains also a power factor clause. The rates stated are based on 0.8 power factor. Should the pumping station load be at a power factor of more than 0.8 then the demand charge is reduced in the ratio of the actual power factor to 0.8 power factor. For example, should the City maintain a power factor of unity (1.0) the billing demand will be eight tenths of the demand charge, namely, 0.8 × $1.56¼ or $1.25 per month per kilowatt.

To obtain the benefits that accrue from this power factor clause synchronous motors will be installed at the high lift station for the main purpose of obtaining a high power factor.

These rates were applied to the loads that are expected at the pumping stations during the years starting with 1928 and ending with 1948 and the resultant costs tabulated under the headings as herein stated. When the electric and steam stations were compared on a basis of total annual costs, the former showed a saving over the latter of about 3 per cent at the outset or initial five year

period. In the later periods, however, the saving in favor of electric drive was overcome and the steam drive showed a saving which increased until it was about ten per cent in the final five year period. It must be realized, however, that these percentages are well within the limits of accuracy of judgment which may now be expressed as to efficiencies and economies to be actually realized during a period of twenty or twenty-five years of future operations.

So far there is a slight advantage in favor of steam. A local factor of unusual significance, however, has practically controlled the situation and has turned the scales in favor of electricity. The estimated cost of the additional water supply works, according to the report of Fuller and Maitland, engineers for these works, is, in round numbers, twenty million dollars. Only eleven million dollars have been voted by the City and a program of new works has to be worked out to fit this amount of money. The saving in investment if electric pumpage were adopted would amount to fully two million dollars for the complete new works needed by the City during the next twenty-five years, and upwards of one and a half million dollars could be saved in the first installation of works, of which about eight hundred thousand dollars would be due to electric high lift pumping. This large saving in investment was the controlling factor in deciding in favor of electric pumping at the high lift station.

SOME EXPERIENCES WITH A STEAM TURBINE DRIVEN CENTRIFUGAL PUMP IN THE ST. LOUIS WATER DEPARTMENT[1]

By Leonard A. Day[2]

Steam turbine driven centrifugal pumps have been used for pumping raw water at the low service station of the St. Louis Water Department for some time; two units of this type, each having a nominal capacity of 40 m.g.d., having been installed in 1912. These units are driven by an impulse steam turbine, very simple in design, consisting of only one high speed turbine wheel. They have been very satisfactory from the stand-point of reliability, the only difficulty being due to cutting of the turbine buckets on the wheel during the time that saturated steam was in use at the plant. With the introduction of superheated steam, erosion has practically disappeared. If the wheel becomes worn, it can easily be removed and rebladed at the plant.

A new turbine driven centrifugal pump having a capacity of 110 m.g.d. against a head of 65 feet was placed in service in March, 1919. This unit is of the conventional geared type, but the turbine, being much larger than the original units, is provided with 13 velocity stages for economy. The operation of this machine has not been as free from difficulties as that of the smaller and more simple single-stage turbines. It was noticed after this machine had been in service for practically two years that a considerable dropping off in capacity took place. It was no longer possible to operate the unit at its full capacity.

At first it was believed that the water end was causing the trouble. Consequently a new impeller and new wearing rings were put in and the water end was completely overhauled. This did not correct

[1] Prepared under the direction of the Council on Standardization, by Committee No. 7, on Pumping Station Betterments. The personnel of the Committee is as follows: L. A. Day, Chairman; J. N. Chester, F. G. Cunningham, L. R. Howson, and L. A. Quayle.

[2] Chairman of Committee on Pumping Station Betterments; Mechanical Engineer, St. Louis, Mo.

the trouble and it was decided that the steam end or turbine should be looked into. Before taking apart the turbine a duty test was made to determine if there had been any dropping off in efficiency since the acceptance test. In the summer of 1923 the first duty test to check the original trials was made, four years and seven months after the unit was put in service, and we found that the duty had dropped approximately 25 per cent as compared with the original test. It was also impossible to pump more than 95 m.g.d. with all of the nozzles on the turbine open. This condition convinced us that there was something radically wrong with the turbine, since the water end had just been overhauled and was in first class condition.

In an effort to correct the choked-up condition of the turbine (we were positive by this time that the steam end was choked or coated) we undertook to dissolve the foreign matter in the turbine with kerosene. About one barrelful of coal oil was pumped in at the throttle with a steam pump as the machine was being shut down. After the use of coal oil, the unit was again tested, the results showing practically no change in capacity or duty. It was concluded that it would be necessary to take down the steam end of this unit, in order to determine just what had caused the loss in efficiency and ability to carry load. After completely dismantling the rotor about one-half of the buckets in the wheels and guide vanes in the diaphragms were found clogged with scale. Figure 1 shows the scale on one of the wheels thrown outward by centrifugal force and completely blocking the outer half of the blading. Figure 2 shows the scale in the guide vanes which are stationary. The scaling was worst in the first stages.

An analysis of the scale showed the following composition:

	Per cent
Silica	17.7
Iron and aluminium oxides	13.7
Calcium carbonate	13.3
Calcium sulphate	0.8
Magnesium carbonate	19.2
Magnesium hydroxide	11.4
Oil	21.1
Moisture	2.8

It will be noted in this analysis that some of the component matter in the scale was oil. The presence of oil aggravated the accumula-

Fig. 1. Scale Deposit in Blading of Rotating Element

Fig. 2. Scale Deposit in Re-directing Vanes on Stationary Diaphragms

Test data

	TEST 3	TEST 11	TEST 13	TEST 20	TEST 21
Date	April 15, 1919	June 8, 1923	Aug. 17, 1923	Jan. 22, 1924	Jan. 22, 1924
Duration, hours	2	3	3	3	1½
Water pumped, m.g.d	101.40	94.81	94.47	99.24	105.4
Net head, feet	65.26	65.76	66.50	64.58	64.82
Steam pressure at throttle, pounds gauge	129.7	122.1	122.7	123.6	123.8
Superheat at throttle, °F	83.8	127.4	104.2	123.7	131.3
Vacuum (reference to 30 inch bar), inches Hg	29.00	28.05	27.85	29.07	29.07
Bled steam pressure, pounds gauge		32.0	27.3	4.25	
Bled steam temperature, °F		292.0	330.0	272.0	
Condensate (from primary heater) °F	73.3	100.0	101.0	56.0	58.0
Temperature water pumped °F	47.0	79.0	80.0	33.0	33.0
Main condensate, pounds per hour	15,433	20,207	20,426	15,039	16,743
Bled and auxilliary steam pounds per hour	1,946	1,992	2,105	2,562	782
Total heat to turbine, B.t.u. per hour	18,696,000	24,273,000	24,300,000	18,860,000	20,840,000
Total work done, foot pounds per hour	2,302,000,000	2,169,000,000	2,178,000,000	2,230,000,000	2,375,000,000
Water h.p.	1,162	1,096	1,100	1,126	1,200
Duty foot pounds per B.t.u. (in millions)	123.2	89.4	89.7	118.2	114.1
Pounds steam per water h.p. hr.	14.93	20.28	20.47	15.63	14.6

Data on unit: In service March, 1919, to October, 1923, a period of four years and seven months, during which it ran 12,230 hours or 30.5 per cent of the time, and pumped 45,000,000,000 gallons against an average head of 59 feet.

Capacity 110 m.g.d. against 65 feet maximum head. Pump, single stage with maximum speed of 352 r.p.m. Turbine, 13 velocity stages, with maximum speed of 3720 r.p.m. Double helical reduction gear, with ratio of 10.56 to 1.

tion of scale by building up a sticky carbonaceous mass. All of the scale forming material, together with the oil, was undoubtedly brought over from the boiler in the steam. In addition to this partial stopping up of the passages there were evidences of cutting action, due, in our opinion, to the erosive action of the solid matter carried in the steam. This cutting action required the replacement of the sealing rings which prevent steam leakage along the shaft, and the reblading of five of the wheels. The high pressure nozzle ring was cut badly, jagged openings having been cut through the thin wall separating one nozzle from the other. This part was also replaced. The wheels which did not require reblading were cleaned with a sand blast, a method which proved to be the best. Soaking in boiling caustic solutions softened the scale, but did not remove it.

After assembling the machine two duty tests were made to determine the gain in economy and capacity. It was found that not only was the full capacity easily obtained, but that the duty had been practically restored as compared with the original tests.

An explanation of the table marked "Test data" follows. The numbers refer to the numbers of the tests.

3. April 15, 1919. One of the acceptance duty tests which represents perhaps the best possible performance of this particular machine under the existing steam conditions.

11. June 8, 1923. The first duty test made to determine the actual loss of capacity and duty. The impeller had been overhauled but the steam end was not investigated. Note that the duty has fallen off approximately 25 per cent as compared with test 3.

13. August 17, 1923. One of several tests made after the steam turbine had been cleaned with kerosene. The duty of the unit remained practically the same.

20 and 21. January 22, 1924. These tests were made after the turbine had been thoroughly overhauled. The duty has been raised from 89 to an average of 116 million foot pounds per B.t.u. This is within 5.5 per cent of the original duty, a very satisfactory performance when it is considered that the impeller by this time had been in use for about three months. Unavoidable errors in observation, it must be remembered, will easily cause 2 to 3 per cent difference in tests of this kind.

In an effort to correct the present conditions we contemplate the use of steam purifiers connected to the boiler outlet nozzles inside the steam drums. It is hoped thereby to eliminate any possibility of the steam carrying foreign matter in an appreciable quantity into the turbine.

It is hoped that this information will not be construed as detrimental to steam turbine driven centrifugal pumps, but that it will point out the importance of investigating any steam conditions which might cause the carrying over of foreign matter into turbines.

Incidentally the importance of test work to determine when extensive repair work should be started and to find out the benefits derived from such work has again been brought out.

HYDROGEN-ION CONCENTRATION AND SOLUBLE ALUMINIUM IN FILTER PLANT EFFLUENTS[1]

By William D. Hatfield[2]

In 1916 Morison (1) published an article entitled "Dose of alum for clarification of waters." His problem was the clarification of a turbid river water, using aluminium sulfate and intermittent twenty-four hour sedimentation periods. From beaker experiments and practical plant operation covering a period of two years, he found that the best results, in clarification, bacteria removal and absence of residual alum in the tap water were obtained when sufficient alum was added to just neutralize one-half the alkalinity of the raw water. He concluded:

1. The alum dose in parts per million should be 1.1 times the alkalinity (expressed as p.p.m. $CaCO_3$).
2. This dose is independent of the turbidity and absolutely dependent on the changes in alkalinity.
3. This treatment is the optimum treatment for complete insolubility of the aluminium hydroxide floc.
4. With treatments of alum greater or less than 1.1 times the alkalinity, soluble aluminium could be demonstrated in the tap water with hematoxylin solution.
5. In the operation of MECHANICAL FILTRATION PLANTS less alum may be used and an aluminium free effluent may still be obtained, because the aluminium hydroxide mat on the filters removes colloidal aluminium sol in the process of filtration.

The following quotation from Morison's article anticipates our present interest in hydrogen ions, and throws some doubt on the accepted mechanism of colloidal precipitation in water purification.

In one respect the writer is unable to bring the above experiments into line with the theory of colloids . . . . ; The optimum dose, the so-called isoelectric point, has been shown in these experiments to be independent of the

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Chemist, Sewage Treatment Plant, Sanitary District, Decatur, Illinois.

amount and nature of the colloid present. (The optimum point can be moved at will by altering the alkalinity of the water, and when the alkalinity remains constant the optimum point is apparently uneffected by qualitative or quantitative changes in the colloids.) It would seem as if the precipitation of the colloids were not so much due to the neutralization of the charge on the sol by that on another sol or electrolyte, as to a certain balancing of the acid and basic ions in solution.

It is interesting to apply the Greenfield-Baker (2) equation for calculating the pH of water to Morison's suggestion. If the isoelectric point is when the alkalinity is half neutralized, then the concentrations of CO_2 and $CaCO_3$ (alkalinity) in the treated water will be equal and will cancel in the equation, and the pH value in any water at the isoelectric point will be 6.5.

$$(H^{\cdot}) = \frac{3 \times 10^{-7}\ (CO_2)}{(\text{alk.})} + 1 \times 10^{-8}$$

$$= 3.1 \times 10^{-7}$$

$$pH = 6.5$$

The concentration of CO_2 originally in the raw water is neglected in this calculation because no data were available. The small amount of probable CO_2 in surface waters, however, would not reduce this figure much more than 0.2 to 0.3 of a pH unit.

Hatfield (3) has shown that reasonably good coagulation of a water with variable alkalinity always begins at a pH value of 7.6 to 7.8, providing the original pH of the water was higher than 7.8; also that this coagulation point was independent of the turbidity. He found that the most efficient point to operate the Highland Park Filtration plant was at a pH value about 7.2. When larger amounts of alum were used to reduce the pH of the treated water below 7.2 too much floc was thrown on the filters and their period of service was shortened. Data given in this paper extend the optimum coagulation and sedimentation zone given in the earlier paper, from the range 6.5 to 7.6 to the range 5.8 to 7.5 pH units.

Buswell and Edwards (4) have shown that, with few exceptions, the effluents from the filter plants in Illinois contain less aluminium than their raw waters respectively, and that the pH values of the effluents range from 6.0 to 7.7 pH units. They contend that, though the curve plotted with pH values and Al_2O_3 in the effluents is not a smooth curve, nevertheless the points trend toward a minimum

Al_2O_3 content at a pH of 6.0. Although this statement is true, it happens that the raw waters of those sources which had an effluent of about pH 6.0 contained, with one exception, less Al_2O_3 to start with than the effluents of the other plants. Their data, therefore, do not show that aluminium hydroxide under the condition of filter plant operation is any more insoluble at pH 6.0 than at pH 7.7. A plot of the decrease in the determined Al_2O_3 between the raw waters and the respective effluents and the pH values do not show that the pH value has any definite effect on the amount of removal of the aluminium which was originally dissolved in the raw water.

Theriault and Clark (5) have shown that from the known acid and basic dissociation constants of aluminium hydroxide, the calculated isoelectric point in dilute solutions is 5.49 or 5.6. They have shown numerous curves plotted on pH-time bases which indicate that, as the amount of alum used approached that usually consumed in water purification plants, the apparent isoelectric point approached 5.5 pH units. Another pH-time curve, where the alum dose was constant and the buffer value varied, gives an apparent isoelectric point at pH 5.9. Their results indicate that, as the solutions become sufficiently dilute to approach the salt concentration of normal surface waters, the isoelectric zones of the pH-time curves become very narrow and the isoelectric point is very definite.

The pH-time curves, similar to those of Clark's, given in this paper were determined on Lake St. Claire water using "filter alum" and the apparent isoelectric point is at pH 6.1 to 6.3. The pH-soluble Al_2O_3 curves were determined on the same water using filter alum and filtering the treated water through the Highland Park mechanical filtration plant or through qualitative filter paper in the laboratory. In these curves the isoelectric zone (minimum solubility zone for $Al(OH)_3$) extends from 5.9 to 7.4 pH units. The differences between Dr. Clark's and these results are probably due to the impurities of a natural water with its dissolved neutral and buffer salts, turbidity and organic matter. The wide aluminium-insoluble zone which I report is probably due to the factor mentioned by Morison, i.e., the effect of mechanical filtration on the removal of colloidal aluminium sol.

During the summer and early part of the fall of 1922 samples of the raw water and the combined effluents were collected during

different alum treatment rates. Liter samples were evaporated, silica removed and iron and aluminium determined as the oxides, according to the A. P. H. A. standard methods. Iron was determined colorimetrically in a separate sample, calculated to ferric oxide and subtracted from the combined ferric and aluminium oxides. In table 1 will be found the results of this series of experiments; while curve I, figure 1, gives the pH-soluble Al_2O_3 data in graphic form.

These data bring out two interesting facts: first, that, when the water is treated with 0.65 grain per gallon or more of alum at a resulting pH of 7.5 or less, the effluent contains less Al_2O_3 than the raw water (confirming Buswell and Edward's earlier data); and second, that, at a treatment of 0.27 grain per gallon and a pH of

TABLE 1

Residual aluminium in the effluent from the Highland Park Filters

SOURCE	ALUM TREATMENT	pH VALUE OF SAMPLE	Al_2O_3 AND Fe_2O_3	Fe_2O_3	Al_2O_3	Al_2O_3 IN RAW WATER PLUS ADDED Al_2O_3
	grains per gallon		*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Raw water	0.00	8.1	1.6	0.36	1.24	1.24
Effluent	0.27	7.8	3.2	0.03	3.17	2.01
Effluent	0.50	7.6	2.6	0.03	2.57	2.66
Effluent	0.65	7.5	0.8	0.03	0.77	3.09
Effluent	0.80	7.4	1.1	0.03	1.07	3.52
Effluent	0.96	7.3	1.0	0.03	0.97	3.97
Effluent	1.25	7.1	0.8	0.01	0.79	4.08

7.8, the water actually has a solvent action on the aluminium floc already in the coagulation basin and on the filters, for the effluent contains 3.17 p.p.m. Al_2O_3, compared to the total of only 2.01 p.p.m. Al_2O_3 in the water after treatment with the alum. From the standpoint of residual alum in the effluent of the Highland Park Plant, it is quite clear that the mimimum allowable dose is about 0.6 grain per gallon of alum. More alum than this minimum is sometimes necessary to remove high turbidities. The question now rises as to the maximum amount of alum that can be used before soluble aluminium is found in the effluent. How would curve I look if completed with higher alum treatments?

The cost of operating the plant at higher alum treatments to satisfy our curiosity was out of the question, so I resorted to labora-

tory methods in order to get data for curves showing alum treatments of the Lake St. Claire water from 0 to 15 grains per gallon. In the following experiments 2 liters of water were treated with a freshly prepared solution of alum, mixed, coagulated and settled for five hours, and filtered through two 10-inch qualitative filter papers. The filtered samples were analyzed according to the methods described above and the results are given in table 2.

Curve II, figure 1, plotted on pH-soluble Al_2O_3 bases from data in table 2 shows that, under the laboratory conditions of these

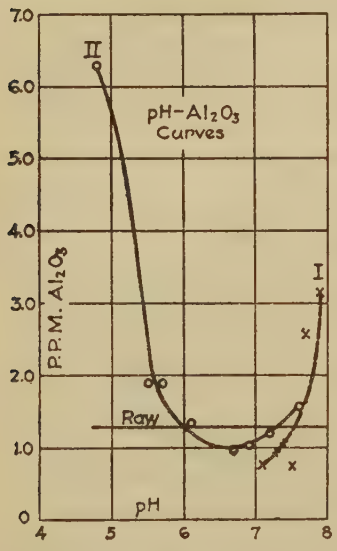

FIG. 1

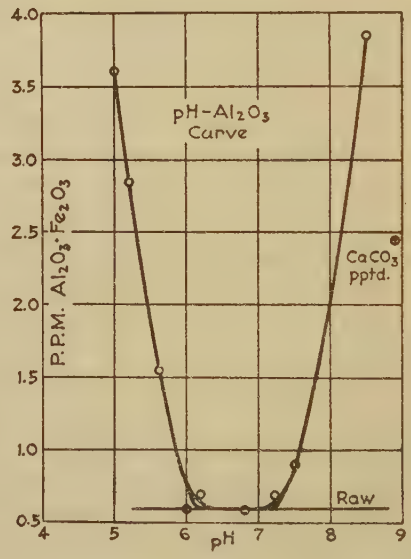

FIG. 4

tests, there is a zone reaching from pH 5.9 to 7.3 in which the effluents contain less aluminium than the raw water. The broken line curve I, plotted from similar data in table 1, shows that in actual practice of mechanical filtration a larger amount of aluminium is removed from the water than by the laboratory filtration through filter paper and that the zone of "less aluminium than in the raw water" is widened to about pH 7.5. It is equally possible that, if the plant experiments included treatments to 15 grains per gallon, the lower extremity of this zone would be about 5.7. A comparison of curves I and II show a sufficiently close relationship between the

laboratory bottle experiments and those of actual plant operation to justify accepting the former results as applicable to practice.

In figure 2 the time, in minutes, required for the first visible floc formation is plotted against the pH values obtained by treating the raw water with from 0 to 15 grains per gallon of filter alum. This curve represents somewhat the same conditions as Clark's pH-time curves mentioned above, except that the aluminium content is variable instead of constant. It does approximate operation conditions more than the Clark curve. Figure 2 shows a minimum, or apparent, isoelectric point at pH 6.3. The curve is not symmetrical because at the lower pH values, where larger quantities of

TABLE 2

Aluminium in filtered waters treated in the laboratory

ALUM	pH VALUE	FILTERED SAMPLE			
		Al_2O_3 and Fe_2O_3	Fe_2O_3	Al_2O_3	Hematoxylin test
grains per gallon		*p.p.m.*	*p.p.m.*	*p.p.m.*	
0.00	7.8	1.3	0.02	1.28	−
0.25	7.6	1.6	0.02	1.58	+++
0.75	7.2	1.2	0.00	1.20	+
2.25	6.9	1.2	0.07	1.13	Faint
4.00	6.7	1.1	0.13	0.97	−
7.00	6.1	1.4	0.16	1.34	−
10.00	5.7	2.3	0.40	1.90	+
12.50	5.5	2.4	0.50	1.90	−(?)
15.00	4.8	7.2	0.93	6.27	+++

alum are used, the forces of mass action cause the floc to form sooner than when smaller concentrations of alum are used.

In the above experiments the pH value was varied by adding different amounts of alum to the raw water. In the following set of experiments the pH value of the water was varied from 3.3 to 9.7 by adding the necessary amounts of sulfuric acid or sodium hydroxide to the raw water. Four liter samples of these waters were then treated with 1 grain per gallon of alum in 4-liter glass-stoppered bottles and coagulation noted hourly. At the end of seventy-two hours equilibrium seemed to be complete; the samples were filtered through 10-inch qualitative filter papers and the aluminium and iron oxide content determined on 2-liter samples. Cor-

rection for iron oxide in these samples was constant at 0.03 p.p.m. and is neglected in the data on this series tabulated in table 3.

The pH-time curve in figure 3, plotted from data in table 3, shows its minimum distinctly between 6.0 and 6.2 pH units, thus indicating 6.1 as the apparent isoelectric point, if this time method

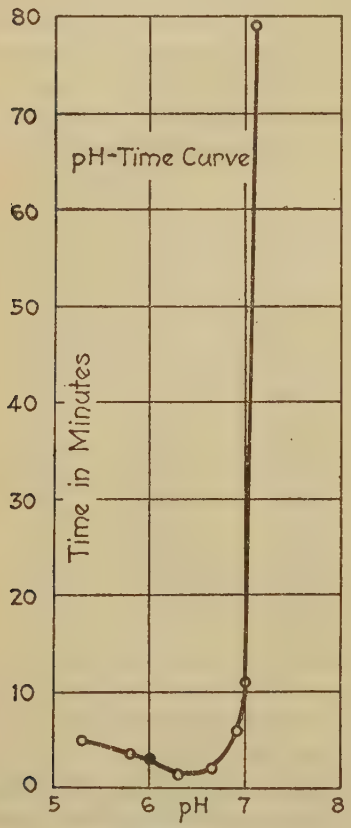

FIG. 2

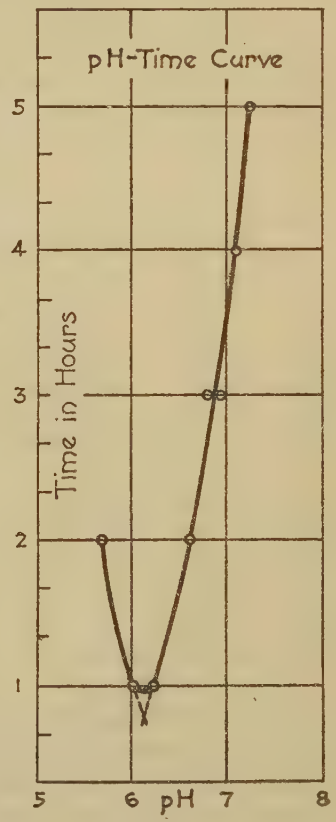

FIG. 3

indicates such a point. The pH-soluble Al_2O_3 curve in figure 4, plotted from data in table 3, shows the minimum solubility zone to extend approximately from pH 6.0 to 7.4.

The data in table 3 clearly indicate the possibility of acidifying water in conjunction with alum treatment. The relative costs of alum-acid treatment and alum treatment alone should be carefully

studied on large scale operations, so I have refrained from calculating costs from my small scale experiments. The use of acid alum is not advisable because acid alum is hygroscopic and would be very unsatisfactory to ship or handle. Ground acid alum for dry feed machines would become sticky,badly caked, and would rapidly destroy the bags in which it is shipped. From every point of view it would be more satisfactory and more scientific to use neutral or

TABLE 3

Effect of acid and alkali on coagulation of water, alum at 1 grain per gallon

pH VALUE OF RAW WATER BEFORE ADDITION OF ALUM	pH VALUE 3½ HOURS AFTER ADDITION OF 1 GRAIN PER GALLON ALUM	FIRST APPEARANCE OF FLOC	pH VALUE OF SAMPLES AT TIME OF FILTRATION (72 HOURS)	Al_2O_3 AND Fe_2O_3	EXCESS Al_2O_3 AND Fe_2O_3 OVER THAT IN RAW WATER	QUANTITATIVE HEMATOXYLIN TEST*
		hours		*p.p.m.*	*p.p.m.*	*p.p.m.*
9.7	9.3		8.95	2.45	1.85	1.5
9.4	9.0	72	8.5	3.85	3.25	
8.9	8.1	22	8.0	1.9	1.3	1.3
8.2	7.2	5	7.5	0.9	0.3	
7.8	7.2	5	7.2			
7.7	7.1	4	7.2	0.7	0.1	0.1
7.4	6.9	3	7.1			
7.0	6.8	3	7.0			
6.7	6.6	2	6.8	0.6	0	0
6.4	6.2	1	6.4			
6.1	6.0	1	6.2	0.7	0.1	0
5.9	5.7	2	6.0	0.6	0	0
5.6	5.6	72	5.6	1.55	0.95	0 †
5.4	5.1		5.2	2.85	2.25	0.4†
4.8	4.7		5.0	3.6	3.0	2.0†
3.8	3.8		3.8	3.75	3.15	
3.3	3.3		3.3	4.25	3.65	2.0†
Raw water untreated with alum.....			7.7	0.6	0	0

* 1 cc. 1:1000 aqueous solution Hematoxylin in 50 cc. sample of water plus 1 cc. saturated ammonium carbonate solution. Allow fifteen to twenty minute for color formation and compare with standards prepared *at the same time* using raw water filtered through a Berkefeld filter, instead of distilled water, and standard filter alum solution. Compare in Nessler tubes viewing the color from the side rather than through the length of the tube.

† This discrepancy in the gravimetric and colorimetric results needs further study. The color method is of course questionable, but there is little doubt that the gravimetric results are too high in this acid region. (Compare with qualitative hematoxylin test in table 2.)

slightly basic alum and apply the acid separately as sulfuric or carbonic acids.

In the practical operation of a mechanical filtration plant it seems, as yet at least, that the isoelectric point of aluminium hydroxide in itself is only of theoretical value, because the complete removal of bacteria, turbidity, color and added aluminium ions is in most cases obtained long before the so-called isoelectric point is reached. It would often be most uneconomical to add enough alum to bring the pH value of the treated water to 6.1, or to 5.5 if you prefer Clark's data. On the Lake St. Claire water 0.6 grain per gallon of alum is usually sufficient to produce the desired results, but it would require 7 and 12.5 grains per gallon to reduce the water to the pH values of 6.1 and 5.5, respectively.

On the other hand the pH-soluble Al_2O_3 curves give us valuable information. In the first place there is shown an optimum pH zone within which, for all practical purposes, soluble, free, aluminium ions do not exist in the effluent. In the second place, the point at the end of this optimum zone which indicates the minimum amount of alum and the corresponding pH value at which complete removal of added aluminium takes place, is of considerable importance to the operator. It is at this "minimum optimum point" that he will operate whenever the conditions of the raw water allow it. When higher pollution, turbiditics, and color require more alum for their removal, the operator will simply use that amount of alum which experience has taught him to use, knowing that when he reaches the lower pH end of the optimum zone more alum means lime or soda ash to take care of the excess alum by keeping the pH in the optimum zone.

Results on Lake St. Claire water and artificially prepared waters in this laboratory indicate that this optimum zone extends from about 5.8 to 7.5 pH units, and although this zone may shift one way or the other in some waters, I am inclined to believe that in the majority of cases it will hold within one or two-tenths of a pH unit. In cases where the pH value of the raw water is low, for example, 6.8, it will be necessary to add enough alum so that the forces of mass action will start the reaction in sufficient time for coagulation and sedimentation to take place before filtration, and therefore the pH value of the "minimum optimum point" of treatment will be less than that of the raw water and the zone of optimum treatment will be narrower than with the more alkaline waters.

A very soft water having very little dissolved buffer salts might have an initial pH of 7.0, but the addition of a small amount of alum would make the treated water too acid, and therefore require artificial alkalinity. The methyl orange alkalinity is a rough measure of this buffer value and for that reason is an indispensable determination until a better method is developed.

This wide zone of treatment has been the salvation of filter plant operators for the last 20 or more years. Think what would have been the efficiencies of past operation, if it had been necessary to treat each water to the exact isoelectric point, be it Clark's 5.5 or Hatfield's 6.1, when they did not know what a pH unit was.

SUMMARY

1. Curves plotted according the Clark's pH-time method from data obtained by treating Lake St. Claire water with alum, show an apparent isoelectric point for aluminium hydroxide under these conditions at 6.1 or 6.3 pH units.

2. Curves are given which show that in filtration the effluents from alum-treated waters are practically free from all the aluminium added as alum when the pH value of the treated water lies in the zone between 5.8 and 7.5 pH units. Mechanical filtration plants operating within this zone will probably not only remove all the added aluminium but also some of the aluminium naturally dissolved in the raw water.

3. A water which has been under-treated with alum and has a pH value of more than 7.5 may have a solvent action on the floc in the sedimentation basin and on the filters such that the effluent will contain more aluminium than that in the raw water plus that added as alum. This is probably also true of an over-treated water.

4. It is firmly believed that the importance of hydrogen-ion concentration has been established in water work and that each year it will be applied more and more to practice.

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TYPES OF PIPE FOR WATER MAIN CONSTRUCTION[1]

By S. B. Morris[2]

HISTORY

Development and improvement in the art of manufacturing and laying pipes for the conveyance of water dates back to early Babylonian days, 4000 years B.C., and is still engaging the minds of manufacturer and user alike. The pipe used by this early civilization was a very crude clay pipe or was composed of stone blocks through which cylindrical holes had been cut. Lead pipes were extensively used by the Romans for distributing water. In the Middle Ages bored logs or lead pipes were used for conveying water. Modern water pipes are made of cast iron, wrought iron, steel, lead, wood, vitrified clay, cement or concrete. In the far east bamboos are still largely used for water pipes of small diameter.

WOOD STAVE PIPE

The first log pipes in America were laid in 1652 for the water works of Boston. These were replaced in 1796 after one hundred forty-four years of service with new log pipes which continued in service until about 1848 when they were replaced with cast iron pipe. Wooden pipes are still being constructed and used to carry water, but it is now the practice to build all pipes larger than 6 inches of wooden staves wrapped with heavy wire or bands. In order to protect the steel wire from corrosion the exterior is usually coated with asphaltum. While wooden mains can be easily tapped under pressure, their use has been substantially given up for distributing purposes and is now largely confined to supply mains, conduits, siphons, and penstocks of large diameter. Wooden pipe lines have the advantage of high carrying capacity which does not decrease with age as in the case of all metal pipes. In heavy soils the wood is very durable, but in dry light sandy soil their life is much shorter.

[1] Presented before the California Section meeting, October 26, 1923.

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CAST IRON PIPE

Cast iron pipe is said to have been first used in England in the fourteenth century. However the oldest cast iron mains now known to exist are 13 to 20 inches in diameter and were laid by order of Louis XIV of France, to supply the town and parks of Versailles from the reservoirs of Picardie. These pipes are in lengths of 1 meter and are joined by means of bolted flanges.

The first bell and spigot cast iron pipe was designed by Thomas Simpson, Engineer of the Chelsea Water Company of London, and was laid in 1785 in 6-foot lengths. The cities of America did not know cast iron pipe until 1817 when the first cast iron pipe in 9-foot lengths was imported from England and laid in Philadelphia. Some of this bell and spigot pipe is now in use after one hundred years of service.

In the past one hundred years the chief evolution in the manufacture of cast iron pipe has been in the introduction of the modern blast furnace and cupola, the use of flux and the improvement of cores permitting longer lengths to be cast. We have stepped from the 1 meter to the 6-, 9- and 12-foot, and within the past ten years, in sizes up to 12 inches, to 16-foot pipe and in some foundries on account of foreign demand to 5 meter (16 foot $4\frac{1}{2}$ inch) lengths. The advantage of the longer lengths in saving bell holes, jointing material, labor and in lessening leakage is obvious.

By 1902 the New England Water Works Association had adopted standard specifications for the manufacture of cast iron pipe, thus putting all manufacturers on an equal footing. This specification however included 10 different thicknesses of pipe for the various pressures. The American Water Works Association adopted specifications May 12, 1908, and reduced the number of weights to 8, only 4 of which are in common use. With decreasing manufacturing costs and price of pig iron, the thinner sections of the New England Water Works Association were given up.

With the greatly increased cost of pig iron, the high freight rates and the sale price of cast iron pipe there grew up during the war a demand for lighter, cheaper pipe. The first response to this new condition was the adoption of higher tensile strength metals by several of the cast iron pipe companies. However, the saving following the slight price recession since the war did not warrant the continuance of these pipes which were only slightly lighter than Standard American Water Works Association pipe and the cost was greater per ton.

The standard practice is now to pour all American Water Works Association pipe vertically in dry sand moulds. Pipe 12 inches and smaller is usually cast bell end up, while larger sizes are cast bell end down. On the larger pipes the spigot ends are cast long and trimmed off to secure sound metal.

Moulding sand is tamped either by machine or by hand around a pattern and within a steel flask. After the pattern is removed the sand is coated with a metallic blacking and dried over gas heaters. The core is made by revolving by power an iron spindle which is to form the center of the core. A twisted hay or excelsior rope is first wound around the spindle. The mud which is mixed in a pug mill is plastered over the hay rope and trued up with a strike. The core is then baked and the final coat of mud applied and again baked and coated with blacking. If it were not for the hay it would not be possible to withdraw the core after the pipe is poured due to the shrinkage of the metal about the core.

DE LAVAUD, CENTRIFUGALLY CAST, CAST IRON PIPE

During the past year the leading cast iron pipe company in America has brought out and offered to the public in commercial quantities a new cast iron pipe, being a radical departure from former standard practice. This pipe is cast centrifugally without a core, by what is known as the de Lavaud process. It was my good fortune last January to inspect this process at Birmingham before placing an order for some 1500 tons of pipe, which is made in diameters varying from 6 to 12 inches.

In the de Lavaud process molten metal is poured into a steel mould of proper diameter revolving in a water jacket. The only core used is a sand core supported on a steel mandrel to form the bell end. A lip over 12 feet long is provided so that the flowing metal is poured first into the bell end after the revolving mould has been brought up to speed. The lip is then slowly withdrawn toward the spigot end, the speed of the mould, the rate of withdrawal of the lip, and the tipping of the ladle of moulten iron all being synchronised so as to give a pipe of proper thickness. The pipe solidifies immediately and is pulled out of the mould from the hub end while still red hot and calipered and weighed, after which it goes to an annealing oven maintained at 1700°F. It is necessary to anneal the pipe to overcome its brittleness from the sudden cooling. While passing through the oven the pipe is rotated to give uniform temperature on all sides.

The de Lavaud pipe is very uniform in cross section, is fine close grained and of higher tensile strength and, therefore, is made thinner for the same pressures than the American Water Works Association standard cast iron pipe.

The annealing does not wholly overcome the tendency of the pipe to be brittle. In laying a good many miles of this pipe we have found that the pipes could be cut much more effectively with rolling cutters than with the ordinary cold cutter. Our experience is that the de Lavaud pipe taps very well and takes an excellent thread. We have found it very difficult to detect all breakage when unloaded from the cars due to the fineness of the cracks and considerable cutting has had to be done on the ditch when it was too late to secure acknowledgments from the carriers.

McWANE, HORIZONTALLY CAST, CAST IRON PIPE

A new development during the past year is the *McWane Pipe*, which is cast horizontally in a green sand mould in 5-foot lengths in diameters from $1\frac{1}{4}$ to 6 inches, and in 5 to 12-foot lengths in 4- and 6-inch pipe. In marketing a thinner lighter pipe than the American Water Works Association standard, the manufacturers of this pipe claim added strength due to the increased depth of the skin obtained by using a green sand mould. This pipe is cast without any bead on the spigot end and with bell end similar to the American Water Works Association specification. To protect the pipe in transit the spigot end is cast a little thicker than the rest of the pipe. This has apparently been successful as the amount of broken pipe received by us in Pasadena by boat and rail is so far less than with other grades of cast iron pipe.

Pipe is furnished either with or without a prepared lead and steel wedge joint. In small sizes it is furnished with two 5-foot pieces with center joint precaulked. Some pipe with center joint of cement has been shipped with success. The smaller pipe is also made with screwed ends so as to connect to ordinary standard screw fittings.

In order to prevent movement of the core when pouring the 12-foot pipe the core is supported near its midpoint by copper chaplets shaped like a collar button with two intermediate corrugations to prevent the copper from being later forced out of the pipe. After the pipe is cast a workman expands this copper chaplet by means of a center punch and hammer. In several thousand feet of this pipe we have so far had two leaks at these copper chaplets. Such leaks can readily be stopped by application of center punch as noted above.

UNIVERSAL CAST IRON PIPE

Another type of cast iron pipe which has been on the market for a number of years is Universal Cast Iron Pipe which is cast horizontally in 6-foot lengths. This pipe has a ground tapered joint and is bolted together with two bolts and without any gasket.

Great flexibility is claimed for this pipe and after being laid in firm ground will not leak after the bolts have rusted out. Universal pipe is made in sizes from 2 to 20 inches and for pressures from 100 to 250 pounds per square inch.

SIMPLEX CAST IRON PIPE

This pipe is quite similar to the Universal, but is bolted together with a prepared joint with lead and jute endless ring gasket for gas or water lines. Pipe varying from 2 to 6 inches in diameter and 5 feet in length is made, but it is not intended for competition with the American Water Works Association standard pipe. It is rather a combination of flanged and bell and spigot joints giving great flexibility. Special fittings with bolts and lugs are provided for use with Simplex pipe.

LAP WELDED STEEL PIPE

The general use of lap welded steel pipe except in the smaller water works systems is becoming less common than it was a few years ago. In the distributing systems of the ten water companies which have been consolidated into the Pasadena City System we have many miles of standard screw, casing screw, old boiler tubes with welded joints, and Matheson joint pipe. I believe everyone is familiar with the use of lap welded standard screw pipe which goes by inside measurement and in sizes above 2 inches has 8 threads per inch and in the casing screw pipe which is sold by outside diameter is lighter in weight and has more threads per inch. For protection from corrosion these pipes are either galvanized, dipped, or dipped and wrapped with roofing paper. Screw pipe comes in random lengths varying from 18 to 22 feet.

Lap welded pipe with welded joints is becoming very largely used for gas, but so far has not been very widely used for water. This pipe comes in lengths of 30 feet or more.

Matheson joint pipe is sold in the same weights as casing and goes by outside diameter. It has a bell and spigot joint similar to cast

iron pipe, but requiring much less lead. It is sold in random lengths of 10 to 20 feet. It has an advantage over screw or welded joint pipe in that it can be made to give high resistance to the flow of stray currents by using cement joints, thus minimizing electrolytic damage.

RIVETED STEEL PIPE

Riveted steel pipe was first used in California about 1852 in the hydraulic mines. Use of riveted steel pipe for water works purposes was begun soon afterward. Our fellow member Mr. Elliott reports that a 30-inch No. 12 gauge riveted iron pipe fifteen miles long was laid by Mr. Hermann Schussler for the Spring Valley Water Company in 1868, some of which continued in full service until 1922 or for fifty-four years.

In the early development of water works in California little cast iron pipe was used owing to its prohibitive cost. At a very early date riveted steel pipe with drive joints and in diameters from 3 to 36 inches was developed with much success. In fact many cities and water companies are still using riveted steel mains for water distribution.

Pasadena first used riveted steel with drive joints in 1884 and much of this pipe is still in use after nearly forty years of service. This pipe is manufactured in random lengths of about 20 feet and is composed of steel sheets 30 to 60 inches in length. Pipe is usually made with single riveted seams up to 6 inches and in larger sizes with double riveted longitudinal seams and single riveted circular seams. The drive joint is 3 to 4 inches in length made by slightly belling the female end and tapering the male end. The rivet heads on the outside of the male end and the inside of the female end must be well ground off and the lap in the sheet well scarfed so the joint will drive readily and make tight.

Pipe is dipped in heavy "D" grade asphaltum of penetration varying with the season in which it is to be laid and in many cases in recent years wrapped with mica covered roofing paper. A stream of hot asphalt is fed in under the paper in addition to the original dip on the pipe thus giving a thick protective coating which on account of the paper is not easily chipped off in laying. After the pipe is placed in the trench gasoline or kerosene is squirted onto the pipe ends and ignited so as to melt the dip. As soon as the dip begins to run the pipe is driven home with a maul in sizes up to 8-inch and with a heavy ram against a steel driving plate in larger sizes.

Pasadena has over 100 miles of riveted steel pipe, 4 to 30 inches in diameter, in its distributing system, all of which has been laid with drive joints. With the exception of one 24-inch line having defective joints we have never had any trouble with leakage at the drive joints. The thickness of our pipes varies from No. 18 to No. 10 gauge.

This pipe is so cheap and economical to lay that we would be using it on much of our new work, if it were not for the expensive pavement which is now being generally used adding to the cost of replacement when this is necessary.

Many water works have given up the drive joint and are laying riveted steel pipe with welded joints and others are using riveted field joints in sizes 20 inches and larger. Drive joints are not generally used with any pipe thicker than No. 8 gauge. Present use of welding apparatus has greatly simplified the installation and locating of fittings as these may now be built up by the water works themselves and outlets placed on the lines wherever needed.

CONCRETE PIPE

This material has generally been used only for supply conduits, although there are now several instances where reinforced concrete is being used for larger mains in water works distributing systems. Concrete pipe has generally been tamped into steel forms and in lengths from 3 to 4 feet. Concrete mixtures have generally varied from $1\frac{1}{2}$:1:$2\frac{1}{2}$ to 1:2:4. Many types of joints have been used varying from bell and spigot to various interlocking poured joints. Obviously the very short lengths have added greatly to the expense of laying.

Recently there has come onto the market 12-foot lengths of reinforced concrete pressure pipe in sizes from 12 to 72 inches in diameter. Three types of reinforced concrete pressure pipe are now being manufactured in these 12-foot lenths. Cylinder pipe with a welded steel cylinder running through the entire length of the pipe and incased in reinforced concrete; poured pipe with bar and mesh reinforcement; and centrifugal pipe made by revolving a mould at high speed causing the concrete, reinforced with bars or mesh or with both, to take its form by centrifugal force. The reinforcement is figured to stand the full hydrostatic head with a unit stress of 10,000 to 12,000 pounds per square inch without giving any tensile value to the concrete. Various steel and lead joints are provided for these pipes.

In the centrifugal concrete pipe the mould revolves at about 2000 feet per minute, rim speed. The impurities and excess water are removed from the interior surface while the pipe is still revolving. Pipes from 12 to 36 inches in diameter are being made. A 24-inch pipe, $2\frac{1}{2}$ inches in thickness, must be revolved for fifteen to twenty minutes. The steel moulds are left on the pipe over night and the pipe cured for six to seven days submerged in water.

Outlets can be provided in the manufacture of this pipe by which it may be tapped under pressure. Centrifugal concrete pipe is successfully being used for pressures up to heads of 200 feet. Price of this pipe was quoted to me in June as about the equivalent of cast iron laid, exclusive of trenching and backfilling, at a price of $45.00 to $50.00 per ton.

In the hillside service of many of our cities it is believed there is opportunity for use of large diameter moderate pressure pipe in the lower pressure limits for which concrete pipe may be used These new developments should be watched with interest by all water works men. In East Orange, New Jersey, a 20-inch pipe recently laid by Nicholas S. Hill, past president of this Association, showed a leakage of only 90 gallons per inch diameter per mile per day.

From the foregoing brief discussion of the various types of pipe being manufactured for water works distribution purposes there is to be noted a greater tendency to produce new and lighter types of pipe to lessen the high cost than has occurred for generations of pipe manufacture. The user of pipe has welcomed these new ideas in the present congested market of little competition. He must study, test and inspect this new pipe, however, very carefully before purchasing it in large quantities.

EFFECT OF DISTRIBUTION SYSTEM DESIGN UPON FIRE INSURANCE RATES[1]

By Louis Stocklmeir[2]

Before commenting upon the distribution design and its effect upon fire insurance rates, it might be well to dwell for a few moments upon the question of how our fire insurance rates are made up, for no doubt there exists in the minds of many people, not directly connected with the insurance world, a somewhat hazy conception as to what constitutes these rates.

Rates promulgated by a bureau usually cover the following features: structures and their contents; rents and rental values; explosion, riot, and civil commotion; use and occupancy; earthquakes; tornado, cyclones and windstorm, growing crops, etc. Each and every one is usually arrived at in a different manner, yet it may possibly be that the formation of a rate is dependent upon another rate, for example, the building fire rate directly affects the contents rate for that building.

Consequently, on account of different methods used for arriving at rates pertaining to the features mentioned above, I shall purposely omit all features of insurance, other than methods of fire rate making on buildings. This will simplify the discussion and provide the best example as to methods used. Buildings regardless of location may be divided into the following general groups:

Class A. Independent steel supporting structure, fire proofed.

Class B. Structure of fire resistant materials, usual form being a reinforced concrete building.

Class C. Outer walls of fire resistant materials, usually brick or reinforced concrete, with wood interior construction.

Class D. Frame.

As addenda to the foregoing general classes, there may be: tile; all steel and mill classifications; iron clad on wood; stucco; brick veneer, etc.

[1] Presented before the California Section meeting, October 26, 1923.

[2] Engineer, Pacific Board of Fire Underwriters, San Francisco, Calif.

It is obvious that each of the general classifications have distinctive merits or deficiencies of their own, and having such, the same should be reflected upon the fire insurance rates; consequently it would naturally follow that the gradation of rates from a basic standpoint only would be in an upward direction from class A to class D. However, the question arises why are final rates sometimes lower on a class C than on a class B building? The answer is that the following features have a tremendous effect on the fire rate, namely, occupancy, building deficiencies, and exposures. I shall endeavor to show this effect more clearly later in the paper.

Our rates may be divided roughly into two groups: (*1*) tariff rates; (*2*) specific rates. These rates are based on the assumption that an assured will insure at least 50 per cent to value, and in cases on certain buildings, should more insurance be carried, there is a corresponding decrease in the rate, and if not that much is carried, provisions are made for a corresponding increase.

1. Tariff rates as a rule are made up by bureaus on information furnished by representatives of companies, authentic maps, etc. This rate may or may not be the final rate, depending chiefly on the occupancy and classification of the risk being insured.

2. Specific rates, on the other hand, are rates based on the personal investigation of the risk in question by some representative of the rating bureau. These rates are usually formed by modification of tariff rates or by the application of special schedules.

To show more clearly the method of tariff rate making, there has been prepared for convenience of application a tariff book in which are listed practically all known occupancies, alphabetically arranged. Following each occupancy and for different building classifications are charges in dollars and cents per 100. These charges vary with the class of building and the occupancy hazard of the building. In this tariff are found also charges and credits for building's deficiencies, together with exposure charges for buildings adjoining or in the vicinity of the risk to be rated. These exposure charges naturally are directly affected by the class of exposing building, its occupancy and the intervening distance. With the above general outline of method of rate making, how is this system applied to towns of various classes, so that buildings in each town will receive their just rates as compared with those in another town. For we know that towns may range in many features from poor to excellent when comparisons are made. In addition, what effect has the water supply and distribution system on tariff rates?

Roughly outlined, the method and answer are as follows: A logical way to make the necessary differentiation would be to modify either the charges against the occupancy hazards for each building classification, the deficiency charges or credits, or the exposure charges. It was with this point in view that there was finally adopted, so that equitable fire insurance rates might be arrived at, a tariff book for California consisting of some six or more sections. Each section has practically the same alphabetically listed occupancies, but in many cases with varying charges. Not only may the occupancy charges be found to vary, but also the building deficiency charges and credits, as well as the exposure charges. Having these varied sections, towns when classified, may easily be placed in the proper section. With a continuation of the refining process, the basic occupancy charges, their exposure charges or any combination are varied by percentage deductions or additions to the various sections.

By the above system (each and every town having been properly classified according to its deficiencies, these deficiencies varying by one point only, and ranging from fifteen upward, the derivation of which I shall explain later) all towns may be designated to a certain section together with the percentage modifications of sections should same be applicable. To tie this method to the topic in discussion we will assume that, on account of deficiencies existing in the water features of a town, their fire department, and other miscellaneous considerations, the number of deficiency points allotted to the town was 39. Of this 39, we will assume that 13 of them are composed of deficiencies within the water system proper.

Now with the 39 points of deficiencies, the building occupancies of that town will fall under a certain section, the basic charge for a drug store in that section will be for:

Class B	160 per hundred
Class C	190 per hundred
Class D	250 per hundred

The building deficiency and exposure charges are added to this for final rate. We will now assume that this town makes enough changes within its water distribution system to eliminate the 13 points. The deficiency points of the town now total 26 and being fewer should enjoy a differentiation in the rate. Hence with 26 points, the town is placed under another section and it happens that the basic charge on the same drug store becomes for:

Class B	150 per hundred
Class C	180 per hundred
Class D	225 per hundred

In this, as well as in the previous case, buildings' deficiencies and exposures are added to get the final rate, modifications in proportionate degree being applied. Hence it is possible that, as cities improve their water distribution system, very often with little additional expense, enough may be dropped from their deficiency point allotment to affect materially fire insurance rates.

Practically all of the foregoing discussion has referred to the tariff rates. We will now enter upon the question of specific rates, the rates usually formed from some modification of the tariff or by application of special schedules.

For example, in the rating of certain frame buildings, there are cases where modification of tariff rates furnish specific rates. It happens that, in certain classes of risks, the size of main together with hydrant would reduce the basic rate on a building of that class, if within certain limiting distance from the hydrant and main. There are numerous schedules in use, and in order to simplify matters as much as possible, I shall employ a schedule which is most commonly used, its application being to A, B and C class buildings, of ordinary occupancy.

The starting point or key rate for any final rate on a building depends on several factors, namely, the basis rate, the city's deficiency points, as before, and classification of the building. The basis rate is uniform for all cities, as it is the computed cost per hundred necessary to conduct business. To this fixed basis is added each particular city's or town's deficiencies. The summation of the two forms a city's rate, which is fixed. To obtain the key rate for a building, as to class, a certain fixed percentage of the above summation is taken, this percentage decreasing in order from class C to class A construction. The total summation gives us a key rate for buildings of class A, B, or C in that town. As an example, assume that:

	cents
Basis rate is	25
City's deficiency points	30
The city's rate is	55

A diminishing percentage of this, and added to it, gives the key rate, on all buildings varying from class C to class A. The final

rate would be ended here, if all buildings of the same class had the same occupancy, with absolutely the same internal deficiencies and no exposures. Hence, in order that each building of a given class may have an equitable rate, each building's deficiencies, i.e., open elevator shafts, open stairways, inferior wall construction; in short, some 40 odd deficiency charges, if such exist, are assigned against the building in question, these usually being in a percentage of the key rate. These charges added to the key rate of the town or city, together with charges corresponding to the occupancy hazard involved, give a final building rate.

The fixed basis is not a variant. The classification of buildings have been taken care of by a diminishing percentage charge in the order from class C to class A construction. Each building has its own particular deficiencies and occupancy, hence there is but one remaining factor, the deficiency points of the town or city under consideration. Assuming that the city's deficiency points amount to 30 in all, part of those points were due to a poor water supply, with numerous poorly laid mains not well gridironed, or the town had outgrown the old water system, in general, the mains being too small, dead ended, etc., and then the town in question lays proper mains, improves its storage capacity, etc., with the result that five (assumed) of the deficiency points against the city are removed. The city's deficiency points drop from 30 to 25 and the city rate becomes 25 + 25, or 50 instead of 55. The key rate of buildings are correspondingly lowered and consequently all rated buildings participate in a rate reduction.

Up to now, I have purposely ignored the methods of preparing deficiency charges, to lay greater emphasis on rate making and the possible effect on those rates of a distribution system.

I shall now endeavor to explain of what those charges consist and their relations to towns and cities, not by means of too much detail, but by utilizing points here and there merely to illustrate the deficiency charges which might possibly be made should those conditions be present. Incidentally I am assuming that the distribution system constitutes everything from the storage to the hydrant outlet. The bureau with which I am affiliated has utilized for many years a system of computing deficiency points based on the following features: (1) Water works, which is divided into some thirteen subdivisions, each with its proper charge. (2) Fire department, similarly divided into thirteen subdivisions, each with its

corresponding charge or charges. (3) General considerations, consisting of twelve subdivisions each with a charge. It may be well to state here that these general considerations take into account such things as police system, streets, conflagration hazard, climatic conditions, previous fire record and similar features. Deficiencies under these three heads, on addition, give the city's or town's deficiency points, which was previously mentioned in the methods of rate making. Of the foregoing the water works deficiency points may run in good conditions from a minimum of 7 to 9 to a higher number depending on the water system.

Subsequent to the initial adoption and utilization of the above schedule, however, there was issued by the National Board of Fire Underwriters, the "Standard Schedule for Grading Cities and Towns of the United States with Reference to Their Fire Defenses and Physical Conditions." This schedule has been adopted by us. The ratio between the two schedules is 1:110. This Standard Grading Schedule is very elastic, in that very small deficiency charges and corresponding credits may be taken into consideration. In all the total number of points of deficiency total 5000 and are divided into the following divisions and relative values:

	points
Water Supply	1,700
Fire Department	1,500
Fire Alarm	550
Police	50
Building Laws	200
Hazards	300
Structural Conditions	700
Total	5,000

From this point on, I shall quote more or less directly from the schedule.

Climatic conditions affect fire losses, by reason of the frequency of fires due to the heating hazard, by retarding the response of fire apparatus, by hampering effective fire fighting during cold weather and storms, by the increase in combustibility due to hot dry weather, and by the greater probability of fires spreading at times of high winds. Also that earthquakes, tornadoes, hurricanes, cyclones, blizzards, floods and other unusual conditions have an influence on the conflagration hazard. These elements are to a more or less degree common to the whole county, and therefore no deficiency is considered in the schedule for normal climatic conditions.

To cover these abnormal conditions, as those just quoted, the originators of the schedule have called these features super-deficiencies and as such have given them chargeable points which are as a rule added, should they exist, to the chargeable points in the schedule proper.

To illustrate more fully, we will take the problem of hot dry weather. In a given town, the deficiency points are represented by the following empirical formula

$$\frac{mt^2}{150d}$$

where m = average number of months per year
t = average monthly mean maximum temperature
d = average number of days per month with 0.01 inches precipitation

The schedule advocates the application of the above to towns which have months having an average mean maximum temperature of 65 degrees or more with six or less days of 0.01 inch or over of rain fall, i.e.,

Average number of months per year	5
Average monthly mean temperature	80
Average number of days per month with 0.01 inch rainfall or greater	4

Then super-deficiency point for dryness $= \frac{5 \times 6400}{150 \times 4}$ or about 53 points.

This charge has several modifications, locality and judgment controlling its proper usage. As to the normal deficiencies of a town or city totaling 5000 points, I will devote the rest of this paper to the 1700 points which are allotted to the water supply. Before entering on this, I want to clear the point as to a town's or city's classification. A first class city or town is one receiving 0 to 500 deficiency points, then on up to ninth class, varying each class by 500 points, the ninth class being one which receives 4001 to 4500 points. A tenth class city or town is one receiving more than 4500 points, or without a water supply and having a fire department grading tenth class, or with no fire protection.

The water supply charges are made under 32 separate items or deficiencies, these charges are made in cases by definite points, in others by points corresponding to the per cent of deficiency. This scale is given as follows:

Deficiency scale

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0%	0	10	25	45	67	90	112	134	156	178	200
1%	1	12	27	47	70	92	114	136	158	180	
2%	2	13	29	50	72	94	116	138	160	182	
3%	3	15	31	52	74	97	119	141	163	185	
4%	4	16	33	54	77	99	121	143	165	187	
5%	5	18	35	57	79	101	123	145	167	189	
6%	6	19	37	59	81	103	125	147	169	191	
7%	7	21	39	61	83	105	127	149	171	194	
8%	8	22	41	63	85	108	130	152	174	196	
9%	9	24	43	65	88	110	132	154	176	198	

Points

It will be found that there is a lesser increment on the scale for the first 30 per cent than for the remainder. Quoting from the schedule:

a deficiency of 10 per cent in good or moderately good conditions has less actual effect, than where conditions are poor. In using the scale either a fractional, full or multiple portion is used depending on item under consideration. Where quantities or numbers are not available, the degree of deficiency is usually classified as follows: Slight = 10 per cent, moderate = 25 per cent, considerable = 50 per cent, serious = 75 per cent and total = 100 per cent. Utilization of these classifications require judgment, since that which would be serious in a large city would only be moderate or considerable in a small one due to the infrequency of fires.

Water supply. From a standpoint of fire protection, a gravity system, one which delivers water directly to hydrants without the aid of pumps is considered ideal. However, the excellent pumping equipment of some cities, so nearly approaches the gravity system in reliability and performance that in the schedule no distinction is made in the two types.

To quote further from the schedule:

Reliable fire protection requires such duplication of all parts of a water system, that with such parts out of service as may reasonably be expected to be inoperative, the system will still be able to furnish the required fire flow.

It has been assumed that a storage sufficient to supply ten hours fire flow during a period of five days of maximum consumption is sufficient to permit the making of repairs, alterations and additions to a water supply system.

Where storage fluctuates 10 per cent in 24 hours, the minimum maintained storage is used in calculations, and should the storage

not be sufficiently elevated and fire engines are not used, the top 25 feet in standpipes can only be considered as storage. Supplies from outside sources are given credit, the amount depending on the good and bad points involved. Two such emergency systems can be considered (*1*) those under same management; (*2*) those under outside control and management. The deficiency of a primary source or system can be offset in whole or in part for any item by the added protection of a secondary source or system. This, however, cannot be applied to fire boats where the same would deliver water through pipe lines which are drained part of the year. Where a water system is utilized and cisterns and the like make suction available, the same can be utilized to offset certain points. No credit is given for above cisterns, etc., should water system not exist. They are then taken into account under Fire Department.

The schedule further states

> that requirements given hereinafter are based in part upon the assumption that the maximum daily consumption is 50 per cent in excess of the average, but in all cases of application the actual average consumption for the year previous shall be taken as the average consumption and the maximum consumption for any twenty-four hours in the past three years taken as the maximum consumption, unless conditions have so changed that this maximum will not occur again.

Fire flow is based upon population, given by the empirical formula $G=1020\sqrt{P}\ (1-0.01)\sqrt{P}$. Where G represents gallons per minute, P population in thousands, the final determination of which is affected by structural conditions and fire department. Ratio of engine capacity to fire flow is 2 to 3.

As to adequacy of water, two features are considered.

1. Ability to deliver fire flow at any pressure down to 20 pounds, except that a minimum of 10 pounds is permissible in high value districts having no deficiency in hydrant distribution, and having no deficiency in hydrant specifications, each hydrant being supplied with a steamer connection. This is considered a measure of the capacity of the system to maintain supply under conditions of conflagration, with the system in full operation. With this as a basis, available flow at 20 and 10 pounds determines deficiency under adequacy of supply.

2. The second feature determining adequacy is the ability of the system to deliver fire flow or part thereof at pressures which permit direct hose usage. For high value districts, this pressure should be

around 75 pounds, or more, depending on static available, heights of structures and engine capacity available in closely built residential districts and in districts where there are not more than ten buildings which exceed three stories in height. The allowable pressure is sixty pounds. This can be reduced to fifty pounds in rural mercantile districts where buildings do not exceed two stories in height and in sparsely settled residential sections.

Two-thirds the fire flow at these pressures may offset in whole or part any deficiency in the engine capacity. To illustrate the 32 charges and subcharges composed of some 1700 points, I will take them in the order that they are usually made.[3]

[3] The remainder of the paper is not reproduced here, since it contains verbatim quotations from the printed "Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions." The Schedule is obtainable in complete form from the National Board of Fire Underwriters, New York City.—*Editor*.

MIXING DEVICES AND REACTION TIME[1]

By Charles P. Hoover[2]

Mr. J. W. Ellms, in reporting on the results of Experiments on the Purification of the Water Supply of Milwaukee, says that, in the treatment of the Lake Michigan water, quick mixing of the chemical with the water is the object sought, and that long mixing appeared to be unnecessary and even harmful in breaking up the floc, and in order to obtain quick diffusion of the chemicals with the water, he used several types of devices, which are described in detail in his report: the fish ladder, the fall, the flume, and finally the hydraulic jump. Mr. Ellms points out that all chemical reactions of the types used in coagulation of water are extremely rapid, their velocity increasing with increasing temperature, so that it becomes a matter of bringing together as quickly as possible the reacting compounds.

On the other hand, the results of Mr. Wilfred F. Langelier's experiments at Sacramento, California,[3] indicate that prolonged agitation is not objectionable, but desirable, and, in the treatment of the turbid Sacramento River water, that it was necessary that the precipitate of aluminum hydroxide be kept in suspension until it has had sufficient opportunity to gather together into clusters a maximum number of the fine particles which give the water its turbidity, and which it is desired to remove. He believes that many existing filter plants are provided with inadequate mixing devices and that in such instances more adequate mixing would result in greater efficiency and economy of operation.

Consideration must be given the fact that these men were working on entirely different water supplies, one being a turbid river water, and the other a reasonably clear lake water; so it is probable that both arrived at the right conclusion as to the best method for treating the particular water on which they were working.

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio.

[3] Engineering News-Record, June 2, page 924, 1921.

PLANT RESULTS AT COLUMBUS AND DEFIANCE

A mixing period of one hour and fifteen minutes, with a velocity of 0.30 foot per second through the mixing tanks at the Columbus plant is not adequate to effect maximum coagulation of muddy Scioto River water, the turbidity of which is in a fine state of suspension. If, for example, samples of water, during the muddy water season, are collected at the outlet of the mixing tanks at the Columbus plant and given additional agitation, say for fifteen or thirty minutes, at a velocity of 0.6 foot per second, an improved floc is obtained, which settles quickly and leaves a much clearer supernatant than settled portions direct from the plant mixing tanks.

Effect of more vigorous agitation than received in the mixing basins at the Columbus plant

DATE (MAY, 1923)	ALUM ADDED	TUBIDITY OF RIVER WATER	WATER PASSED THROUGH MIXING TANKS, ALLOWED TO SETTLE 30 MINUTES TURBIDITY OF SUPERNATANT	WATER PASSED THROUGH MIXING TANKS, AGITATED 30 MINUTES AT 0.6 FOOT PER SECOND. ALLOWED TO SETTLE 30 MINUTES. TURBIDITY OF SUPERNATANT
	grains per gallon			
15	9	600	55	15
18	7	270	55	10
19	5	160	20	2
Average..	7	343	43	9

Mr. H. T. Campion, Superintendent of Water Works at Defiance, Ohio, calls attention to the fact[4] that, under ordinary operating conditions at the water softening plant at Defiance, the water leaving the carbonation chambers has at all times a better and more distinct floc than the water entering, and he says that this may be due to the additional agitation caused by blowing the CO_2 gas into the water, or, as an alternate explanation, he says there may be some unsolved reactions taking place, which improve the floc. The writer has seen the secondary floc in the carbonation chambers at defiance, and is of the opinion that it is due to the additional agitation.

[4] Second Annual Report of Ohio Conference on Water Purification, page 133, 1922.

LABORATORY AGITATION EXPERIMENTS AT COLUMBUS

Experiments were made at Columbus, to determine:

1. Velocities required to keep the precipitated chemicals in suspension.

2. The effects of short and long periods of mixing and agitation.

These experiments were made on turbid water with aluminum sulphate only, and on hard water, using lime, soda-ash and alum in its treatment.

The equipment used in the experiments consisted of three agitating units, the speed of rotation and size of paddles of which could be regulated or easily changed. The paddles revolved in glass jars, 6 inches in diameter and 9 inches deep, and, in order that constant or desired temperature could be maintained in the water under treatment, each of these jars was slipped inside a larger jar, provided with an inlet water pipe at the bottom and an outlet pipe at the top, so as to permit the circulation of water of the desired temperature around the jars.

RESULTS OBTAINED BY AGITATION IN TREATMENT OF TURBID WATER

It has already been pointed out that a period of one hour and fifteen minutes with a velocity of 0.3 foot per second through the mixing tanks at the Columbus plant is not adequate to effect maximum coagulation of turbid water. A number of experiments were therefore made in the experimental plant to determine the effect on coagulation with velocities of 0.13 foot per second, 0.22 foot per second and 0.60 foot per second, the agitation period being thirty minutes, and also by bringing together, as quickly as possible, the coagulant and the water by vigorous shaking for thirty seconds. All of the samples were allowed to stand twenty minutes, after which the supernatant was poured off and the turbidity was determined. In all cases the results were better in samples agitated at the higher velocities, and it was possible to get better results on water having a turbidity of 325 parts per million with 2 grains of alum with a velocity of 0.60 foot per second than with 4 grains at a velocity of 0.13 foot per second, and to get as good results with 2 grains at 0.6 foot per second as with 4 grains at 0.22 foot per second. River water, having a turbidity of 325 parts per million, and treated with

4 grains of alum, agitated for 20 minutes and allowed to settle twenty minutes, showed the following results at different velocities.

Effects of agitation at varying velocities

SAMPLE NUMBER	VELOCITY	TIME OF AGITATION	TIME OF SEDIMENTATION	TURBIDITY
	foot per second			*p.p.m.*
1	None			325
2	Vigorous	30 seconds	30 minutes	*
3	0.13	30 minutes	30 minutes	90
4	0.22	30 minutes	30 minutes	30
5	0.60	30 minutes	30 minutes	2

* Not determined, but not noticeably different from no. 1.

These results were demonstrated several times, once for Mr. Waring, Assistant Engineer of the Ohio State Department of Health, once for Mr. A. E. Kimberly, Consulting Engineer, Columbus, Ohio, and for the assistant chemists at the Columbus plant, Messrs. Melick, Meckstroth and Kaiser.

Coagulation results attained on Columbus water at velocities of 0.6 per second can be approached only, time and temperature being the same, if quick mixing, or, low velocities are used by adding an excess quantity of alum, as indicated below.

Effect of one hour agitation at velocities of 0.6 foot per second and short, vigorous agitation on turbid Scioto River water

TURBIDITY OF RIVER WATER	TURBIDITY RESULTS, OBTAINED BY AN AGITATION PERIOD OF		ALUM USED
	Thirty seconds	One hour	
p.p.m.	*p.p.m.*	*p.p.m.*	*grains per gallon*
575	500	380	2
575	150	10	4
575	50	3	6
575	25	1	8

The results obtained in experiments to determine just how long the agitation period should be were not very consistent, temperature and nature of the water treated being important factors. Therefore, the author does not wish at this time to recommend any definite agitation time, but prefers to wait in order to make many

more experiments before attempting to do so. A general impression, however, gathered from the results of our experiments, indicates that the period for turbid water, like that of the Scioto River, at 16°C., is between twenty and thirty minutes. See the following table, showing the average results of two experiments. River water, having a turbidity of 300 parts per million was treated with 4 grains of alum, and agitated for periods of from thirty seconds to one hour.

Effect of varying time of agitation

SAMPLE NUMBER	PERIOD OF AGITATION	VELOCITY OF AGITATION	TURBIDITY	TEMPERATURE
		foot per second	*p.p.m.*	*°C.*
1	30 seconds	Vigorously shaken	130	16
2	5 minutes	0.60	80	16
3	10 minutes	0.60	50	16
4	20 minutes	0.60	20	16
5	30 minutes	0.60	18	16
6	45 minutes	0.60	18	16
7	60 minutes	0.60	14	16

RESULTS OBTAINED BY AGITATION ON WATER SOFTENING

Samples of clear, hard, Scioto River water, treated with 8 grains per gallon of lime, 5 grains per gallon of soda-ash, and 1 grain per gallon of aluminum sulphate were agitated at 0.13, 0.22 and 0.60 foot per second and allowed to settle twenty minutes, after which they showed the following turbidities.

Effects of agitation at varying velocities on softened water

SAMPLE NUMBER	TIME OF AGITATION	VELOCITY	SEDIMENTATION TIME	TURBIDITY
	minutes	*foot per second*	*minutes*	*p.p.m.*
1	1	Vigorously	10	200
2	20	0.13	10	115
3	20	0.22	10	105
4	20	0.60	10	30

Samples agitated at 0.13 foot per second showed a large amount of floc to be settled to the bottom of the container. Samples agitated at 0.22 foot per second showed floc settled toward the

bottom, but not deposited, whereas, at a velocity of 0.60 foot per second, the floc was evenly distributed, none settling out. Results at Columbus indicate that the velocity must be more than 0.30 foot per second, but need not be more than 0.60 foot per second to keep the precipitated chemicals in suspension.

Twenty nine samples of river water were treated with lime, soda-ash and alum and agitated for periods ranging from thirty minutes to twenty-four hours, but the temperature factor was not controlled or maintained constant. The results obtained in this series of tests are shown in the following table.

Effects of prolonged agitation on water softening reactions

SAMPLE NUMBER	PERIOD OF AGITATION	TOTAL HARDNESS	REACTION OBTAINED*
	hours	*p.p.m.*	*per cent*
1	0.5	103	87
2	1	103	87
3	2	89	91
4	4	79	94
5	8	71	96
6	16	59	100
7	24	66	98

Note: Hardness of the raw water was 399 parts per million. 13 grains per gallon of lime, 9.5 grains per gallon of soda-ash, and 0.5 grains per gallon of alum were added. Temperature averaged 2

*Assuming complete reaction at 16 hours.

The results show that the hardness was reduced from 399 parts per million to 59 parts per million, the lowest result was obtained after sixteen hours agitation and that 87 per cent of the reaction accomplished took place in the first thirty minutes.

Whether this reduction in hardness was due to the continuous agitation or simply to the time which was allowed for reaction became the question to be determined, so the experiments were repeated and unagitated samples were run as blanks. The average results of these experiments are shown in the next two tables, one set of samples treated at a temperature of 22°C., and the other at 15°C.

Effects of prolonged agitation and time on water softening reactions

Averages of duplicate experiments

CONTINUOUS AGITATION		BLANK WITH SHORT AGITATION + REACTION TIME		
Period of agitation	Reaction accomplished	Period of agitation	Reaction time	Reaction accomplished*
Temperatures averaging 22°C.				
hours	*per cent*	*minutes*	*hours*	*per cent*
0.5	91	30	0.5	89
1	93	30	1	92
2	95	30	2	97
4	97	30	4	96
8	100	30	8	100
Temperatures averaging 15°C.				
0.5	72	30	0.5	72
1	78	30	1	78
2	82	30	2	82
4	85	30	4	85
8	91	30	8	91
16	100	30	16	100

*Assuming complete reaction in 8 hours at 22°C. and in 16 hours at 15°C.

The results of these experiments indicate that prolonged agitation is not necessary, for at 22°C., 89 per cent of the reaction accomplished took place in the first thirty minutes agitation period, and at 15°C. 72 per cent of the reaction took place in thirty minutes, and that the balance of the reaction that was accomplished was obtained as effectually by simply allowing reaction time as by continuous agitation. These results are also duplicated in plant operation.

Eighty-nine per cent of the reaction accomplished at the Columbus plant takes place in the mixing tanks, one and one-half to two hours. Four per cent takes place in the fifteen hours through the settling basins and seven per cent in passing through the filters. These are the results of 16,000 tests over a period of fifteen years. The hardness of the river water, the hardness of the water at the entrance to and outlet from settling basins and the effluent from the filters is shown below.

Average hardness

	p.p.m.
River water	271
Water at entrance to settling basins	117
Water at outlet of settling basins	110
Filtered water	98

The percent of reaction accomplished through the mixing basins in different months of the year are shown in the next table.

Hardness removed in the mixing tanks

	per cent
1908 to 1923, December, January, February	87
1908 to 1923, March, April, May	87
1908 to 1923, June, July, August	91
1908 to 1923, September, October, November	90

These figures are rather startling, because they indicate that large settling basins are not so necessary for water softening as has been supposed, although, Mr. Wm. R. Copeland, formerly Chemist in Charge of the Columbus Water Softening and Purification Works, now with the Milwaukee Sewerage Commission, has pointed out that large settling basins are of advantage in that they serve as equalizers in case of over- or under-treatment of water.

AGITATING DEVICES

The types of mixing devices used in water purification plants, are, briefly, baffled tanks, with various combinations, the combination of baffles and orifices, tanks provided with rotating paddles or propellers, or a combination of two propellers, wherein one propeller rotates in one direction and one in the opposite direction. This latter type gives very vigorous agitation. Another type of mixing device that is soon to be tried out at Columbus is the Dorr agitator, which consists of a suitable tank, containing a slowly revolving mechanism, which allows the coagulated particles to settle to the bottom where they are scraped to the center and, by means of an air lift, elevated through a hollow, vertical, central shaft, and distributed evenly over the surface, whereby a continuous, evenly distributed circulation is kept up and motion is maintained within the mass, and not only near the bottom and sides, as is the case with tanks provided with insufficient rotating paddles, or paddles operated at too low speed.

Great developments have been made in rotating paddle agitators as a result of experiments in connection with the design of the Sacramento filtration plant under the direction of Mr. Charles Gilman Hyde. Mr. Harry N. Jenks, who was connected with these experiments, has told me that, in order to get a uniform velocity throughout the entire agitating tank, it was necessary to have the area of the paddles 25 per cent of the area of the vertical cross section, and, with this ratio, 0.6 of a foot velocity can be maintained in the coagulation tanks at Sacramento by having the paddles make one rotation in three minutes.

The paddles in the agitating tanks at the Sacramento plant are swung from the paddle arms by means of plate clamps, the paddles thus being allowed to assume a more or less horizontal position when the agitating device is started, but the weight of the paddles is such that, when motion in the tanks is attained, the paddles assume a vertical position. This is to take the load off of the motor in starting up the agitators.

If the proper relation of the area of the paddles to the area of the central vertical section of the tank is 25 per cent, then the speed of rotation required to get any velocity wanted is easily calculated.

The advantages of mechanical agitators over the usual baffled mixing tanks are as follows:

1. They are probably less expensive to construct.

2. For a single mixing tank a more compact arrangement is possible, and therefore can be more readily housed or covered.

3. They remove the necessity of lifting the water the extra two or three feet necessary to pass water through baffled mixing tanks, and, although agitators require power to keep them running, the cost of operation, if a proper drive is provided, should be less than the cost of the additional lift of the water.

4. They provide greater flexibility. Most plants are built in the beginning with over-capacity, and the plant is usually designed to get the desired velocity at the full capacity of the plant; consequently, less velocities are attained when the plant is operated at rates lower than the maximum, whereas with the mechanical agitators, additional paddles may be easily added, or paddles removed, or the speed of rotation may be easily changed, and the velocities desired, easily obtained.

5. They provide greater accessibility.

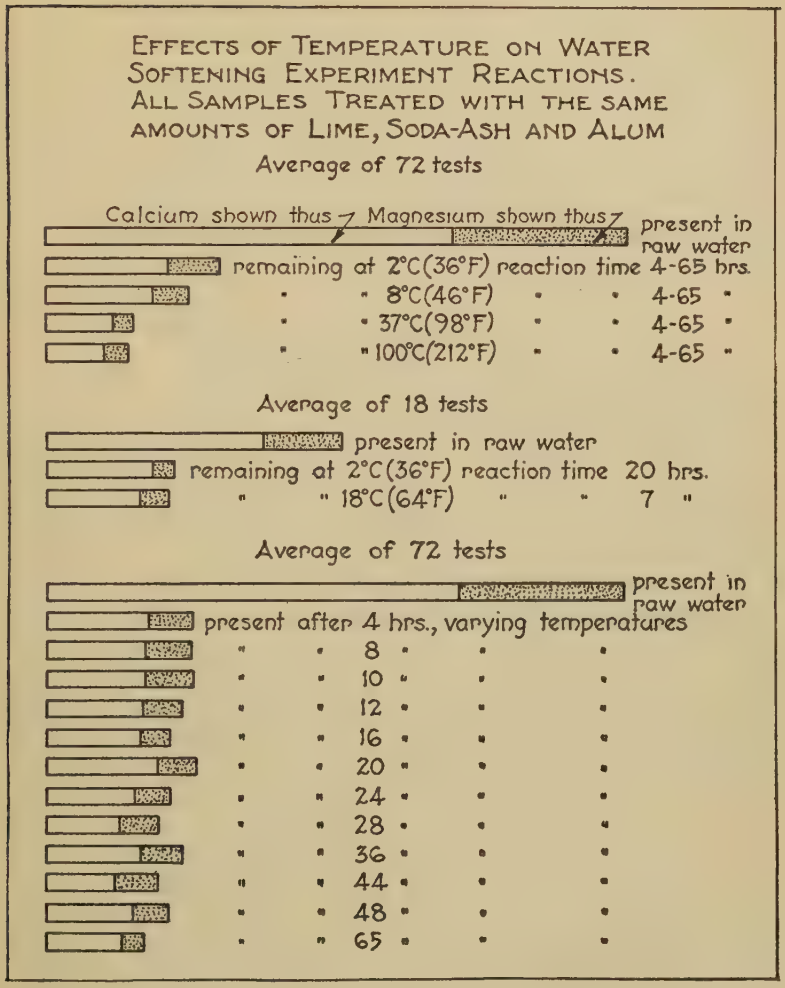
EFFECTS OF TEMPERATURE ON WATER SOFTENING EXPERIMENT REACTIONS. ALL SAMPLES TREATED WITH THE SAME AMOUNTS OF LIME, SODA-ASH AND ALUM
Average of 72 tests
Calcium shown thus
Magnesium shown thus
present in raw water
remaining at 2°C(36°F) reaction time 4-65 hrs.
" " 8°C(46°F) " " 4-65 "
" " 37°C(98°F) " " 4-65 "
" " 100°C(212°F) " " 4-65 "
Average of 18 tests
present in raw water
remaining at 2°C(36°F) reaction time 20 hrs.
" " 18°C(64°F) " " 7 "
Average of 72 tests
present in raw water
present after 4 hrs., varying temperatures
" " 8 " " "
" " 10 " " "
" " 12 " " "
" " 16 " " "
" " 20 " " "
" " 24 " " "
" " 28 " " "
" " 36 " " "
" " 44 " " "
" " 48 " " "
" " 65 " " "

FIG. 1

REACTION TIME

The data in figure 1 show that

1. Temperature is a much more important factor in water softening reactions than time.
2. At higher temperatures less calcium and magnesium remain in solution than at lower temperatures.
3. The reduction of calcium and magnesium drops almost proportionally as the temperature increases.
4. The difference in the removal of calcium and magnesium in sixty-five hours time is not greatly different from the removal in four hours time.

WATER CONTAINING MAGNESIUM SALTS DIFFICULT TO SOFTEN

Waters containing magnesium salts are more difficult to soften than waters containing only calcium. The results of laboratory experiments indicate that magnesium carbonate is much more difficult to remove than magnesium sulphate.

Sixty-five per cent of the hardness of the Scioto River water is due to calcium salts and 71 per cent is removed, whereas only 52 per cent of the magnesium is removed.

Solutions containing 39 parts per million of magnesium as magnesium sulphate, and 43 parts per million of magnesium as magnesium carbonate, and half and half mixture of the two were prepared. All three were treated with the theoretical amount of lime necessary to precipitate the magnesium and the results obtained are shown in the table below:

Reaction of lime with magnesium salts

SAMPLE NUMBER	MAGNESIUM BEFORE TREATMENT	MAGNESIUM PRESENT AS	ANALYSIS AFTER TREATMENT				Mg REMOVED
			Magnesium	Alkalinity			
				Total	Phenol-phthalein	Caustic	
	p.p.m.						*per cent*
1	43	$MgCO_3$	39	190	79	0	9
2	39	$MgSO_4$	10	36	23	10	74
3	41	$MgCO_3$ and $MgSO_4$	26	76	45	14	37

It will be noticed that 74 per cent of the magnesium as magnesium sulphate was removed, whereas only 9 per cent of the magnesium as magnesium carbonate was removed.

MAGNESIUM REDUCED BY OVERTREATMENT

In order to reduce the hardness of water high in magnesium salts to the lowest possible degree, it is necessary to use an excess amount of lime, then neutralize the excess lime with soda-ash, this is in addition to amount necessary to combine with permanent hardness leaving residual or excess sodium hydroxide in the treated water.

The following are the results of analyses of samples of raw and softened water from the Buckeye Steel Casting Company, Columbus, Ohio.

Effects of overtreatment on softened water

Results are expressed in parts per million

	RAW WATER	SOFTENED WATER
Alkalinity (total)	337	92
Alkalinity to phenolphthalein	0	70
Alkalinity (caustic)	0	48
Calcium	161	6
Magnesium	43	3
Total hardness	579	27
Total hardness (grains per gallon)	34	Less than 2

The following are the results of analyses of samples of water from the water softening plant of the Chicago, Milwaukee and St. Paul Ry., at Scotland, South Dakota. Mr. C. H. Koyl is Chief Engineer of Water Service and Mr. J. S. Eastman in charge of plant operation. Analysis was made by Mr. A. A. Chambers, Chief Chemist.

Effects of overtreatment on softened water

Results expressed in parts per million

	RAW WATER	SOFTENED WATER
Calcium	225	7
Magnesium	126	2
Total hardness	1080	26
Total hardness (grains per gallon)	63	Less than 2

These results show that it is possible to reduce, by excess treatment, hardness from 579 to 1080 parts per million to less than 30 parts per million (less than 2 grains per gallon).

The results of our experiments indicate that it is impossible to reduce the hardness of water containing a large amount of magnesium carbonate to a low figure unless excess lime is used, for by treating water containing magnesium carbonate with just sufficient lime to combine with it, the magnesium is reduced only 30 per cent and the alkalinity is reduced less than 1 per cent, indicating that the lime simply combines with the carbonates to form a basic carbonate. By adding 2 grains per gallon excess lime, the alkalinity is reduced 70 and the magnesium 88 per cent, respectively.

SPLIT TREATMENT

When it is not desirable to have excess sodium hydroxide in the treated water, then, in order to reduce the hardness to as low a figure as possible, split treatment should be used, that is, treat as large a portion of the hard water as possible to get maximum reduction of hardness, then neutralize the excess sodium hydroxide by raw water. The proper proportion may be ascertained only by knowing the analysis of the water to be softened. The following tables show what may be accomplished by split treatment.

Effects of split treatment

	Hardness p.p.m.
Raw water	333
25 per cent receiving all chemicals and neutralized with 75 per cent raw water	79
50 per cent receiving all chemicals and neutralized with 50 per cent raw water	79
75 per cent receiving all chemicals and neutralized with 25 per cent raw water	100
90 per cent receiving all chemicals and neutralized with 10 per cent raw water	156
Raw water	305
25 per cent receiving all chemicals and neutralized with 75 per cent raw water	96
100 per cent receiving all chemicals	133
Raw water	329
25 per cent receiving all chemicals and neutralized with 75 per cent raw water	126
50 per cent receiving all chemicals and neutralized with 50 per cent raw water	114
75 per cent receiving all chemicals and neutralized with 25 per cent raw water	99
100 per cent receiving all chemicals	145

The tables show that, by proper split treatment, the hardness was reduced 72, as against 55, per cent for the straight treatment.

CONCLUSIONS

1. Results of plant operation and laboratory experiments indicate that velocities of 0.3 foot per second do not provide sufficient agitation for the treatment of turbid water or for water softening, but that the velocity does not need to exceed 0.6 foot per second.

2. Coagulation results obtained on turbid water at velocities of 0.6 foot per second may be obtained at lower velocities only by adding an excess amount of coagulant.

3. A short mixing period of twenty or thirty minutes at 0.6 foot per second velocity is more effective than a mixing period of one and one-half hours at 0.3 foot per second velocity.

4. Mechanical agitators are less expensive to build, more compact obviate the necessity of lifting the water the extra two or three feet necessary to pass through baffled mixing tanks and provide greater flexibility and accessibility.

5. Temperature is a more important factor in water softening than time.

6. Waters containing magnesium salts are more difficult to soften than waters containing only calcium, magnesium carbonate being especially hard to remove.

7. Magnesium salts may be precipitated by overtreatment with lime.

8. By overtreatment with lime, then neutralizing the excess lime with sodium carbonate, waters having a hardness of 572 to 1044 parts per million may be reduced to a hardness of less than 30 parts per million, or less than 2 grains per gallon.

9. If it is not desirable to use excess treatment, better water softening results are obtained by split treatment than by the ordinary method of applying all of the chemicals to all the water under treatment.

DISCUSSION

WILFRED F. LANGELIER:[5] The writer is interested to note that Mr. Hoover's observations with regard to the most effective and

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economical coagulation of Scioto River water with alum confirm in most important details the results of our studies conducted in the Sanitary Engineering Laboratory of the University of California, and later at Sacramento, as published in the writer's paper in 1922, to which Mr. Hoover has made reference.

Mr. Hoover finds that coagulation was most effective with vigorous initial agitation, followed by a twenty- to thirty-minute period of mixing, at a velocity of approximately 0.6 foot per second. This compares with our conclusions, which were stated as follows: "The initial velocity should be fairly high, say 2.0 feet per second. In each succeeding tank the velocity should be reduced gradually until in the last tank the minimum velocity shall be just sufficient to keep the floc in suspension" also "an actual mixing period of twenty to thirty minutes is somewhat more than ample, but on account of short-circuiting (which must occur in any type of continuous-flow basin) provision should be made for a somewhat longer theoretical retention period, say forty minutes."

In attempting to explain the divergent conclusions obtained by Mr. Ellms with lake water at Milwaukee and those obtained with the Sacramento River water, reference is made to the dissimilar character, particularly with reference to turbidity, of these waters. The writer wishes to state that the water of the Sacramento, although very turbid for short periods each year, was comparatively low in turbidity during the period of the experiments. In fact, before concluding the experiments it was deemed advisable to try the addition of fine clay to the water to simulate these very high turbidities. The lake water at Milwaukee varied in turbidity from 6 to 160 parts per million whereas the Sacramento River water turbidities ranged from 10 to 200 parts per million. The writer does not believe, therefore, that any difference in conclusions may be properly attributed to this factor. In fact, the writer's observations indicate quite the opposite conclusion, namely, that waters of low turbidity require higher velocities and longer periods of agitation than do more turbid waters. Prior to the Sacramento studies, observations were made with different waters of varying turbidity, color, alkalinity and hydrogen ion concentration, and, with the possible exception of very turbid waters, we did not find any waters which were not more effectively and economically coagulated by the type and period of agitation which we have described.

The water treated at the San Pablo Filter Plant of the East Bay Water Company of Berkeley, California, is very similar in character

to Lake Michigan water. We found at this plant that we were enabled to reduce the dosage of alum nearly 50 per cent by simply increasing the period of agitation from approximately five minutes to a period of fifteen minutes. The design of the mixing and coagulating basins in this plant, however, is such that only a portion of this saving is possible at the present time. Further extension of the mixing period will necessitate rather extensive changes, involving difficult construction work.

A similar experience was recently encountered at the filtration plant at Eureka, California. At this plant a water of high color and low alkalinity is handled. The coagulating basin is very small and there is but slight provision for agitation or mixing. A 3-liter sample of water removed from the outlet end of the sedimentation basin showed practically no floc and was quite turbid. This sample was agitated by imparting to it a swirling motion and in about two minutes a heavy floc made its appearance. This it seemed was a most remarkable demonstration of the effectiveness of motion in the coagulation of water.

Mr. Hoover's studies and observations in the field of water softening are always interesting and instructive. In his paper he shows that the usual operating differences in temperature exert a very material effect in the effectiveness of softening with chemicals, especially for the shorter periods. In this connection the writer wishes to point out that, whereas the chemical and physical reactions involved in the coagulation of water with alum on the one hand and the softening with chemicals on the other hand are similarly influenced by agitation, they apparently are not similarly influenced by changes in temperature. Well-controlled coagulation experiments in our laboratory with waters varying from practically freezing to boiling temperatures gave almost identical results. These results are confirmed by those recently published by Baylis in this JOURNAL (May, 1923) in connection with his observations in the coagulation of the water of Gunpowder River. He states that "There is every indication that temperature alone has very little effect." These observations of Baylis and also my own are not in agreement with earlier published references on this subject.

In conclusion, the writer wishes again to affirm his faith in mechanical mixing devices, particularly circular coagulating basins, as evolved from the Sacramento experiments. The studies and conclusions of Mr. Hoover constitute further justification of this departure from standard practice.

THE HYDROGEN ION CONCENTRATION OF LIME TREATED WATER AND ITS EFFECT ON BACTERIA OF THE COLON-TYPHOID GROUP

By R. D. Scott[1] and G. M. McClure[1]

It has been observed over a considerable period of time that lime treatment of water results in a marked lowering of its bacterial content. Hazen (1888) at the Lawrence experiment station noted a high percentage removal of bacteria from sewage, following lime treatment. Fuller (1899) conducting tests on the treatment of the Ohio river water noted an effective bacterial removal after the addition of lime, but attributed it to coagulation and sedimentation. The first work on the lime treatment of water with regard to removal of organisms of the colon-typhoid group was that of Houston (1911) who found that, following the addition of sufficient lime to Thames river water to leave a slight excess, Bact. coli were destroyed in from five to twenty-four hours. Hoover and Scott (1913) confirmed Houston's results and found also that both Bact. coli and Bact. typhosum were destroyed following the addition of just enough lime to change bicarbonates to normal carbonates.

A reasonable explanation of lime sterilization, in the light of recent research on the behavior of bacteria in media of varying hydrogen ion concentration, is that it is largely due to the low hydrogen ion concentration of lime treated water.

The following references support this view: Shohl and Janney (1917) found that Bact. coli in urine were destroyed at pH 9.2 to 9.6 and that Bact. typhosum showed no growth at pH 8.8. Schoenholz and Meyer (1921) using several strains of Bact. typhosum in broth cultures buffered to from pH 8.6 to 8.9 noted a removal of 99 per cent. Neilson and Meyer (1921) working with buffered peptone solutions found that Bact. typhosum was destroyed at pH 9.2 to 9.4. Using higher concentrations of peptone they consider that pH 9.6 to 9.8 may be necessary. Scheer (1922) using phosphate buffer solutions found that Bact. coli were destroyed in three hours at pH 9.65 and in twelve hours at pH 9.43. At pH 9.32 the organisms were not killed in twenty-four hours. Cohen, (1922) using dilute buffer solutions observed Bact. typhosum sterilization in

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twenty-four hours at pH 9.5. He found that Bact. coli survived at this pH. Whipple (1922) in a review of the work of Houston attributes the bacterial effect of lime treatment to hydrogen ion concentration.

EXPERIMENTAL WORK

The work described in this paper was carried on for the purpose of studying the relation of the hydrogen ion concentration of treated public water supplies to their Bact. coli content. As a preliminary a sample of river water was treated with varying amounts of lime and the alkalinity and pH then determined. Results are shown in table 1.

TABLE 1

pH of sample of Scioto River water after lime treatment

GRAINS PER GALLON 92 PER CENT CaO	ALKALINITY			pH 24°C.
	Phenolphthalein	Total	Caustic	
	p.p.m.	*p.p.m.*	*p.p.m.*	
0	0	117	0	7.45
2.92	6	55	0	8.71
4.38	10	36	0	9.35
4.96	15	34	0	9.38
5.84	17	32	2	9.56
7.30	47	56	38	10.35

Six Ohio water purification plants were then selected in which the treatment employed was such that a wide range in pH would be covered. Three of these plants use lime to the extent of complete lime softening, two use smaller amounts and one uses no lime. Samples of settled water were collected from these plants, representing water after coagulation and softening, if employed, but prior to either filtration or chlorination. These samples were collected by the plant operators and mailed at once to the Department laboratory, being received within twenty to forty-four hours after collection. On receipt of the samples determinations were made immediately of Bact. coli, alkalinity and pH.

In making the alkalinity and Bact. coli determinations, Standard Methods of Water Analysis of the American Public Health Association were followed. All aerobic non-spore forming organisms which fermented lactose with gas production were classed as Bact. coli, no attempt being made at further sub-division. Gas formers recorded in the tables as not of the colon group failed in every instance to grow on Endo, and were presumably anaerobes.

METHOD OF MEASUREMENT OF pH

In measuring the pH values, the electrometric method, using the hydrogen-electrode, was employed. A type "K" Leeds and

TABLE 2

Filter influent samples (low hydrogen ion concentration)

PLANT	DATE COLLECTED	ALKALINITY			pH	BACT. COLI (FIVE 10 CC. TUBES)	
		Phenol-phthalein	Total	Caustic		Positive tubes	Gas formers other than Bact. coli
	1923	*p.p.m.*	*p.p.m.*	*p.p.m.*			
Youngstown	March 26	38	48	28	10.44	0	0
	March 27	35	44	26	10.36	0	0
	April 2	29	39	19	10.19	0	0
	April 3	29	39	19	10.20	0	0
	April 10	30	49	11	9.73	0	0
	April 11	40	52	28	10.32	0	0
	April 16	25	32	18	10.18	0	0
	April 17	28	36	20	9.82	0	0
	April 23	30	40	20	10.05	0	0
	May 1	25	35	15	10.30	0	0
Defiance	March 28	35	48	22	10.36	0	1
	March 30	18	36	0	9.69	0	4
	April 4	22	35	9	9.17	0	2
	April 12	31	46	16	10.32	0	0
	April 13	25	42	8	9.88	0	1
	April 18	20	35	5	9.77	0	0
	April 19	16	34	0	9.29	0	2
	April 25	28	41	15	10.33	0	1
	April 26	28	42	14	10.27	0	0
	May 2	31	48	14	9.88	0	1
	May 3	31	48	14	10.02	0	0
	May 10	25	44	6	9.78	0	0
Bellaire	April 12	45	52	38	9.81	0	1
	April 16	29	41	17	10.33	0	0
	April 18	21	34	8	9.95	0	0

Northrup potentiometer was used, measurements being made against a normal potassium chloride-calomel electrode.

A Hillebrand electrode was used in a hydrogen cell of 25 cc. capacity. Commercial electrolytic hydrogen gas, purified by bubbling

through alkaline pyrogallol and potassium permanganate solutions, was passed over the electrode in a stream vigorous enough to surge the solution about the electrode. The entire set-up was checked before and after each series of measurements by means of a standardized

TABLE 3

Filter influent samples, (high hydrogen ion concentration)

PLANT	DATE COLLECTED	ALKALINITY			pH	BACT. COLI (FIVE 10 CC. TUBES)	
		Phenol-phthalein	Total	Caustic		Positive tubes	Gas formers other than Bact. coli
	1923	*p.p.m.*	*p.p.m.*	*p.p.m.*			
Cincinnati	March 26	8	35	0	8.30	3	0
	March 27	8	35	0	9.12	5	0
	April 2	8	35	0	8.94	3	2
	April 9	8	40	0	8.63	3	0
	April 16	6	40	0	8.70	5	0
	April 17	2	39	0	8.08	5	0
	April 24	8	32	0	8.25	5	0
	April 30	6	39	0	8.71	5	0
	May 1	8	48	0	8.90	5	0
Niles	March 28	8	36	0	9.14	5	0
	March 29	5	34	0	9.00	5	0
	April 4	8	35	0	8.20	5	0
	April 11	9	42	0	8.77	5	0
	April 18	9	32	0	8.70	5	0
	April 25	5	28	0	8.54	5	0
	April 26	4	24	0	8.65	5	0
	May 3	15	26	4	9.19	0	1
Sandusky	March 28	0	95	0	7.88	5	0
	April 5	0	80	0	7.35	5	0
	April 11	0	86	0	7.88	5	0
	April 19	0	82	0	7.67	5	0
	April 25	0	80	0	7.61	5	0

buffer solution. The pH values were calculated from the formula: $\text{pH at } 25°\text{C.} = \frac{\text{E. M. F.} - 0.283}{0.0596}$. In case the temperature at which a measurement was made varied from 25°C., a correction was made.

In practically all the samples worked with, there was a slight, gradual increase in the measured E.M.F. with continued passage

of hydrogen through the solution. This was not great enough, however, to prevent readings of the E.M.F. to an accuracy of plus or minus 0.2 millivolts, corresponding to a pH correction of about plus or minus 0.01.

The results of the examination of the samples are shown in tables 2, 3 and 4.

TABLE 4

Raw waters

PLANT	SOURCE OF SUPPLY	DATE COLLECTED	ALKALINITY	pH	BACT. COLI (NUMBER OF POSITIVE TUBES)	
					Five 1 cc. tubes	Five 0.1 cc. tubes
		1923	*p.p.m.*			
Youngstown	Mahoning River	April 24	5	5.05	5	5
		April 30	12	7.03	5	5
Defiance	Maumee River	May 2	165	7.96	2	1
		May 10	175	8.21	4	0
Bellaire	Ohio River					
Cincinnati	Ohio River	April 30	35	7.26	5	1
		May 2	40	7.41	5	0
Niles	Mahoning River	April 25	19	6.44	5	5
		April 28	28	7.02	5	5
		May 3	8	4.33	5	5
Sandusky	Sandusky Bay of Lake Erie	April 25	98	8.05	2	0
		May 2	92	7.57	5	5

DISCUSSION

The plants from which the samples were collected may be divided into two classes on the basis of the pH of the settled waters. In the samples recorded in table 2 the pH was usually greater numerically than 9.5, while in the samples shown in table 3 the pH was constantly less numerically than 9.5. It follows that the actual concentration of hydrogen ions in the samples of table 2 is *less* than in the samples of table 3.

The bacterial results are in very marked contrast. Bact. coli were not found in 50 cc. volume in any sample from the first group

of plants (low hydrogen ion concentration), but were present with one exception in 50 cc., and usually in 10 cc. volumes in the samples from the second group of plants. (Higher hydrogen ion concentration.) A total of 47 samples of settled waters was examined. The Bact. coli content of the raw waters is shown in table 4. One cubic centimeter tubes were as a rule positive. The inference is strong that the contrasting results on these settled water samples are accounted for entirely by differences in pH.

If this conclusion is sound, that organisms of the colon-typhoid group do not survive long in waters so treated that the hydrogen ion concentration is lower than about pH 9.5,[2] (the numerical value of pH is here greater than 9.5), then it would seem that water purification plants, which employ a treatment process such that the settled water attains a pH of this order, possess a distinct advantage over other types of plants. While the effluents from the latter type of plants may as a result of efficient filtration and chlorination be entirely satisfactory bacterially, and fully equal in this respect to that of the first type of plants, yet one type has two factors of safety: filtration and chlorination, while the other has the additional factor of low hydrogen ion concentration.

NATURE OF TREATMENT REQUIRED FOR LOW HYDROGEN ION CONCENTRATION

When a natural water is treated with lime to such an extent that all of the alkalinity is in the form of normal carbonates, as indicated by the phenolphthalein alkalinity being just one-half of the total or methyl orange alkalinity, then its pH will be, at ordinary temperature in the neighborhood of 9.5. This value was based on the following data: Laboratory treatment of water with lime, table 1. Determination of the pH of dilute sodium carbonate solutions.[3] Determination of pH of treated public water supplies, tables 2 and 3.

The hydrogen ion concentration expressed by pH 9.5 is probably not low enough to be effective under all conditions in removing

[2] As the temperature at which the pH was determined was considerably higher than that of the samples as collected, the actual pH values were less numerically than recorded. Thus in some cases the pH was about 9.1 instead of 9.5 as recorded.

[3] It was observed that the pH of dilute Na_2CO_3 solutions at 22°C. was:

Alkalinity, p.p.m. in terms of $CaCO_3$	50	100	500
pH	9.55	10.20	10.50

organisms of the colon-typhoid group, neither is it practicable in plant control to hold the alkalinity exactly in the carbonate form; it is necessary in practice to carry several parts per million of caustic alkalinity, otherwise bicarbonate alkalinity will at times be present with a resultant increase in hydrogen ion concentration. Temperature changes have a material effect. It was found that increasing the temperature of a sample of softened water from 8° to 27°C., changed the pH from 9.89 to 10.32. Thus in cold weather higher caustic alkalinity would be required to produce a bacterially safe pH.

It is believed that pH 10.0 to 10.3 should be sufficient to provide a reasonable margin of safety. This pH is ordinarily attained through the addition of lime to the extent of a caustic alkalinity of 10 to 20 p.p.m. The caustic alkalinity may be and at some plants is removed by carbonating.

CONCLUSION

References are cited which indicate that bacteria of the colon-typhoid group are destroyed in media of low hydrogen ion concentration, the limiting value being in the neighborhood of pH 9.5.

Results of the examination of samples from municipal water purification plants are presented which indicate that this limiting pH here also applies.

The point is raised that those plants employing a process, for example, lime treatment, in the course of which the water attains a pH of this order, may possess an advantage over others in bacterial efficiency.

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SOME WATER TREATMENT PROBLEMS IN ONTARIO[1]

By A. V. Delaporte[2]

The treatment of the majority of water supplies of Ontario presents few new problems to the designing engineer. The Great Lake waters are clear and colorless with the exception of the Detroit River and possibly Lake Erie. The problems involved in the treatment of these waters comprise the removal of effects of local pollution and occasional turbidity caused by storms. A number of municipalities use springs, spring creeks or deep wells. Most of these present no particular problem. Some, however, require treatment for the removal of iron, excessive CO_2, H_2S or for softening. In Northern Ontario and in the Ottawa and Trent River systems, which might be described as peaty waters, there is an appreciable amount of organic matter and a definite colour. These waters generally carry but slight turbidity, excepting storm water, and are comparatively soft. The Central and Western drainage systems such as the Thames, the Grand River and Kettle Creek, have a high turbidity and are classed as hard waters, that is they have a high incrustant content. Some of the smaller lakes or bays that are utilized as municipal supplies require treatment for plankton.

A paper on pretreatment of water was given by Messrs. Dallyn and Delaporte before this Association at the last mid winter meeting and there have been few developments since. It has, however, been demonstrated that a fine filter will retain in the form of hydrate all the aluminium added as alum, irrespective of the pH value (within certain limits), agitation or time of reaction. This would seem to limit the value of the determination of the pH value in filter operation to preventing over-dosages or adjusting the reaction of a water to prevent corrosion. This is true of practically all the waters of the province with the exception of those classed as peaty waters. There seems to be a definite relationship between the volume of floc required to precipitate turbidities and remove color and the volume

[1] Presented before the Canadian Section meeting, February 29, 1924.

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of turbidity and depth of the color, irrespective of the pH value. In other words, a definite amount of an alum floc can only absorb and remove a definite amount of color or turbidity in a certain time. If there is a higher color or greater turbidity than is being removed at a definite dosage then the dosage must be increased, or if there is more alum floc than is necessary to remove the color or turbidity then the dosage can be decreased irrespective of the pH value. This is not true at all times. Traces of some substances appear to retard or inhibit the above reactions.

In the conversion of wood fibre or cellulose into peat, lignite and coal, there seems to be a very gradual elimination of the hydrogen, oxygen, and carbon with the result that the substance undergoing lignification becomes relatively rich in carbon. The carbon which is thrown off in combination with oxygen and hydrogen is probably responsible for those organic acids found in peaty waters. These acids are sometimes exceedingly complicated bodies such as ulmic acid ($C_{18}H_{14}O_6$) or crenic acid ($C_{12}H_{12}O_8$). In other cases simpler bodies such as glycollic acid ($C_2H_4O_3$) or formic acid (CH_2O_2) occur. These acids are all derived from peat. Complete oxidation would convert the cellulose into carbonic acid and water, but there are many intermediate stages in the process. One of the stages appears to be the formation of a substance which has been called formyl cellulose. This substance is only slightly soluble in water and can only exist in soft waters which contain little or no CO_2. Waters containing formyl cellulose are generally on the border line between acidity and alkalinity and have a corrosive action on iron, zinc or lead pipes. Such a water takes up oxygen readily from permanganate and when distilled yields a volatile acid which shows the characteristics of formic acid. When treated with lime a yellow colored deposit settles out, the oxygen consumed value drops sometimes to the extent of four-fifths and on distillation no volatile acid is evolved. This would appear to offer a possible method of treatment of this type of water. Some of these organic compounds do not affect the results of titrations with standard acids and alkalies but have an effect on the precipitation of and flocculation of aluminium hydrate, retarding the reaction and in some instances preventing the formation of a floc. This was illustrated in experiments with the chemical precipitation of sewage. Some samples would give an excellent floc and clear supernatant liquor and others, for no apparent reason, would not give an alum floc. It is not safe to predict what will

happen upon the addition of alum to waters containing organic matter. Hydrogen ion concentration values, acidities or alkalinities determined by use of dyes as indicators give no indication of the presence of these substances. The only satisfactory method of determining what will happen is by actual treatment with alum. The Provincial Board of Health has recently secured an electrolytic apparatus for both acidimetric and alkalimetric estimations and determinations of hydrogen ion concentration. By the use of this apparatus it is hoped that it will be possible to determine the presence of organic acids to which the indicators commonly used are not sensitive.

Reazin Lake, which is the source of Burkes Falls water is a water of this class. It is very interesting from several different aspects. An analysis shows the following results, in parts per million:

TOTAL SOLIDS	RESIDUE AFTER IGNITION	Fe_2O_3	Al_2O_3	CaO	MgO	Cl	SO_3	Na + K	H_2S	OXYGEN CONSUMED	FREE AMMONIA	ALBUMINOID AMMONIA	NITRITES AND NITRATES
121.6	35.0	2.3	0.6	6.5	5.3	2.0	5.3	Trace	0.61	12.9	0.4	2.3	0.0

The H_2S was determined over twenty-four hours after taking the sample, so that that figure is probably low and the SO_3 high.

This water also contains an aerobic, spore forming, lactose fermenting bacillus. This organism has a central spore and is non motile. It appears to possess all the B. coli reactions and has its appearance in growth, with the possible difference that some colonies are slightly larger and more granular than typical B. coli colonies. Spores do not show in new cultures, but on keeping the culture forty-eight hours spores develop.

Some years ago a Bell filter was installed on this supply and through some misunderstanding it was not operated. The Provincial Board is at present assisting with an experiment with this filter. This supply and the operation of this filter will provide a fertile field for research into waters of this character, as this water contains more peaty matter in solution than any other supply in Ontario. The loss on ignition of 86.6 p.p.m. was due almost entirely to oxidation of dissolved organic matter. At an early date more data will be available dealing with the problem of treating this class of water.

Two of the filter plants operating on Lake Ontario have experienced difficulties, although the trouble was from different sources. One filter, of the gravity mechanical type, encountered serious difficulty in operating during the period a year or two ago when the lake was filled with dead or dying fish known as ale-wives. The filtering surface in two or three hours would become almost impervious owing to a slimy substance mixed with fish scales which appeared to be the product of the decomposition of the fish. Various expedients were tried; the difficulty was finally overcome by rearranging the settling basin, which, after very slight alteration, retained the substances which were the cause of the trouble. Recently a slow sand plant encountered a similar difficulty. The water passed through a sedimentation tank to the filter. After some stormy weather the filters could only be operated for about eight hours. A very fine turbidity passed through the settling tank and stopped the filters. This was a suspension of blue clay, apparently caused by the scour of wave action on a blue clay bottom. It appeared to settle quite readily in the laboratory and by rearrangement of the baffles in the basin it is hoped to prevent a recurrence of the trouble. Filter units which are equipped with settling basin, coagulating basins or storage basins to provide for the pretreatment of the water before filtration are able to meet such conditions when they arise. These filters, had they been without settling basins, could not have continued to operate.

It has been generally accepted that turbidities of over 50 p.p.m. cannot be economically removed by filtration alone, and that for higher turbidities it is essential that the turbidity be reduced by settling before filtration. The type and amount of turbidity which will overload any plant varies with the plant arrangements and retention tanks prior to filtration offer distinct advantages to the plant operation in providing flexibility in management and economy in alum and wash water.

At Chatham, great difficulty has been experienced in filtering Thames River water after storms, even with a settling period of several days. The settling basins were unable to produce a water suitable for filtration. In March, 1923, the municipality, assisted by the Provincial Board, undertook an experiment to determine what could be done. A baffling system of sheet piling was constructed in the storage reservoir. Under average conditions it provided an observation period of two hours and a final settling

period of twenty-four hours from the time the alum was added. The preliminary storage did not reduce the turbidity below 200 p.p.m. To secure a filtered water with a turbidity of less than 10 it was necessary to reduce the turbidity of the filter influent to less than 75 p.p.m. The initial turbidities varied from 150 to 1500 p.p.m., the alkalinity from 148 to 182 p.p.m. and the pH value from 7.9 to 8.2. A dosage of 5 g.p.g. of alum reduced the turbidity at the end of twenty-four hours storage to 50 to 60 p.p.m. from 200 to 600, and pH value to 6.8 to 7.2. The resulting filter effluent under these conditions had a turbidity of less than 10 and was physically unobjectionable.

At the plant, experiments were conducted with sulphuric acid and alum for the purpose of manipulating the pH value. These demonstrated that, irrespective of the pH value, at least 4 g.p.g. of alum were necessary to precipitate the turbidity and that the acid would be but an additional expense. Other experiments were made with lime, soda ash and permutit. The results with the lime showed that, unless lime was added in excess, the reacting and settling period took several hours, accompanied by an increased pH value. Similarly the soda ash and permutit appeared to be of no benefit in this respect.

Experiments at Essex, Forest, and Richmond Hill with aeration have been undertaken, with some success, in endeavors to remove H_2S, excessive CO_2, iron or taste from decomposing organic matter. Owing to the severe winter in Ontario, aeration by spraying the water to be aerated is not practicable. Diffuser plates, such as are used in the activated sludge process, were installed and air pumped through the diffuser plates by a small air compressor.

The town of Essex secures its water supply from three deep wells. One, the Garrow well, is situated about a mile from the pump house. The other two, designated as the North and South wells, are located within the pump house in the centre of the town. All three wells are pumped into a reservoir, 25 feet in diameter and 50 feet deep, located under the pump house. This is connected by a 10-inch opening with another reservoir, or pump well, elliptical in shape and 25 feet deep..

The attention of the Board was first attracted to this supply by the extraordinary chlorine requirement for sterilization. Laboratory tests showed that it took 35 to 40 p.p.m. of chlorine to give a trace of residual chlorine with this water. Analysis of the water showed that it contained 1.4 to 2 cc. of dissolved oxygen per litre and 9 to 10.5 p.p.m. of H_2S.

For aeration purposes a diffuser plate 1 foot square was placed at a depth of 30 feet in the centre of the large reservoir. Air was supplied from an air compressor delivering 5 to 7 cubic feet of air per minute.

After aeration was commenced, it was found possible to reduce the rate of application of chlorine to 4.1 pounds per twenty-four hours, a net saving of over 50 pounds of chlorine per day. This gave a trace of residual chlorine at all times. The dissolved oxygen in the water was increased from 2.0 to 4.5 cc. per litre, the H_2S was entirely removed and the CO_2 was decreased from 6.6 p.p.m. to 3.9 p.p.m. If the reservoir had been of a design which facilitated aeration and there had been a greater supply of air available, it is certain that the chlorine dosage could have been reduced still further.

An experiment at Forest was undertaken to determine the feasibility of aerating a highly carbonated deep well supply (40 p.p.m. CO_2) in order to eliminate objectionable taste and certain medicinal properties. The free CO_2 was entirely eliminated with fifty-five minutes aeration and the dissolved oxygen increased from 2.1 to almost 9.0 cc. per liter in the same period. This was accompanied by a complete removal of the objectionable properties of the water.

The town of Richmond Hill secures its water from a spring creek. The creek is dammed to form a shallow lake several acres in extent. This pond during the summer is filled with various types of aquatic plants, becoming practically a marsh. The surface becomes very warm and the heavy weed growth aids stratification by tending to prevent movement of the water. Water from this pond is passed through a mixing chamber, sedimentation tank, and gravity mechanical filters to a clear water well. From there it is pumped to a stand pipe. The water consumption is very small in the town, so that the ordinary plant operation is to filter and pump a few hours on two or three days a week just enough water to fill the stand pipe and clear water well. Consequently the water is in the system for possibly a month and in the outer edges of the town probably six weeks.

During the winter, when the creek and pond were covered with ice, the water in the mains developed an objectionable color, odor and taste due to iron and organic matter. The application of alum to the raw water was discontinued and a diffuser plate 1 foot square was placed in the sedimentation chamber in such a position as to give a maximum of agitation, compressed air being forced through

from a small gasoline engine which had been converted into an air compressor. Despite the fact that the amount of air available was insufficient and that the chemical results show only slight improvement in the water, the physical improvement was very marked and out of all proportion to the chemical improvement noted. A portion of the iron in the raw water was precipitated and was removed on the filters. The dissolved oxygen was increased from an average of 0.3 to 2.3 cc. per liter and the organic matter was partially oxidized. This resulted in practically an entire removal of the objectionable physical properties of the tap water. The odors, taste, color and sediment which developed in the mains before aeration disappeared entirely or were reduced to such an extent as not to be objectionable. Only once or twice since aeration was commenced has sediment or odor developed in the water in the mains.

In midsummer, the conditions noted in the winter also prevail, in part due to the lack of motion in the pond. The water at the bottom, protected from the heat of the sun and from circulation or mixing with the warmer surface water by the weed growth, presents all the characteristics of the water during the winter months.

Aeration is not carried to completion at Richmond Hill due to the small capacity of their air compressor. The results obtained indicate that with adequate aeration the objectionable constituents could be entirely eliminated. This supply would be materially improved if there were a greater consumption of water in the town so that the plant operation would be continuous and the water would not be standing in the system, producing what amounts to dead end conditions.

Complaints as to taste are ever present. It is in part a psychological problem. There are always with us those unfortunates who can be counted on to detect taste in water if there is any chance, however remote, of a taste. Disregarding them, there is a wide difference in the sensitiveness of the sense of taste of different people, and with the same people with different substances. It may be generally accepted that most people cannot detect the taste of free chlorine under 0.4 p.p.m. introduced into pure lake water, and only a few hypersensitive people can detect a chlorine dosage under 0.3 p.p.m. Therefore, if the chlorine dosage is adjusted so that there is never more than 0.3 p.p.m. residual chlorine there should be no complaints of a chlorine taste except where some local situation is involved. The so-called chlorine taste is caused by minute traces

of chlorine compounds of tar derivatives, the so-called trichlorphenols and chlorine compounds of certain substances of unknown constitution and origin which occasionally occur in a chlorinated water. These tastes are offensive and no certain method of elimination of these compounds can be offered from the water works standpoint. It is sometimes beneficial to increase the dosage of chlorine. A number of investigators are working on this problem now. At present the only sure solution is to eliminate the trouble at its source and prevent the disposition of water carrying these objectionable constituents in a place where it can pollute a municipal water supply. Incidentally, gas works and coking plants do not need to dispose of this water by discharging it into the water courses of the Province. All the waste water can be utilized in quenching the coke, provided storage is available.

The tastes and odors from the breaking up of organic forms are sometimes very objectionable. In an experiment recently carried on at a municipality using a small weedy river as a source of supply it was noted that the adjustment of the chlorine dosage eliminated the weedy taste. Unfortunately, the color standards for the control of the chlorine dosage were made for summer conditions. This winter, with a clear water, the standards are off color and have led to an over-dosage of chlorine which has been responsible for a real chlorine taste.

PROGRESS REPORT OF COMMITTEE NO. 5 ON WATERSHED PROTECTION[1]

Surface water supplies are derived from catchment areas of widely varying character and hence the degree of water purification and water protection likewise vary between wide limits.

To illustrate these principles the Committee submits five contributions prepared by district engineers in the Bureau of Engineering of the Pennsylvania Department of Health.

These reports of observation and procedure cover typical or unique problems in Pennsylvania, ranging from the protection of practically uninhabited watersheds to the more extensive and complicated problems on watersheds where sewage and industrial wastes from densely populated districts are distinctly prejudicial to the sources of public water supplies.

The paper presented by Mr. Mark deals with watersheds practically uninhabited, but subject to chance contamination by hunters, fishermen and berry pickers. The reservoirs do not provide long-time storage. These watersheds are made subject to sanitary regulations for sportsmen's camps as well as routine patrol and inspections by the water company.

The case discussed by Mr. Glace is of an inhabited watershed, long-time storage facilities and intensive sanitary control. An interesting feature is the special authority conferred by the State Department of Health on a representative of the local water company for enforcement of sanitary regulations on the watershed.

The contribution of Mr. Matter considers a public water supply obtained from three streams, two of which are relatively clean, but the third is subject to sewage contamination and after storms is turbid. The storage afforded the two better sources of supply has

[1]This report contains contributions from five of the district engineers of the Bureau of Engineering, Pennsylvania Department of Health, prepared under the direction of Committee No. 5, W. L. Stevenson, Chairman, T. DeL. Coffin, Katonah, N. Y., J. A. Foulks, Newark, N. J., S. A. Greeley, Chicago, Ill., W. V. Locke, Boston, Mass., R. J. Newsom, Lynn, Mass., F. M. Randlett, Portland, Ore. and S. P. Senior, Bridgeport, Conn.

been considered sufficient, but the dangerous source of supply entered the reservoir at a point too near the intake to provide proper reduction in turbidity and bacterial content. The required safeguards, pending filtration, include enlargement of the main storage reservoir with relocation of the intake, construction of a small dam on the more dangerous stream, strict sanitary control of the watersheds, and disinfection of the water before delivery to the consumers.

A unique case is reported by Mr. Fortenbaugh. A water supply obtained from mountain streams is impounded in a series of storage reservoirs. A stream tributary to the upper storage reservoir was acid from mine drainage and has an unsewered village near its headwaters. When the city desired to intercept the acid mine drainage it was permitted, provided that a sufficient quantity of acid mine drainage be still allowed to enter the stream to act as a disinfectant, on account of the possible sewage contamination from the village.

The paper presented by Mr. Siebert considers the rather complicated problem of regulation of the discharge of sewage and industrial wastes on a large, densely populated watershed above the intakes of water filtration plants. The present contamination of the stream is so great that, at times, tastes and odors persist even after purification of the water by most elaborate and refined methods. Extreme care is necessary in the operation of the purification plants to prevent water of a dangerous character being served to the public. The policy adopted for protection of the watershed is interesting, since it recognizes the necessity of safe public water supplies and also gives due regard to reasonable economic requirements upon municipalities and essential industries.

The five contributions follow in the order above mentioned.

PROTECTION OF THE WATERSHED OF WHITE DEER CREEK AND SPRUCE RUN, UNION COUNTY, PENNSYLVANIA

By Coleman B. Mark[2]

A water district flanking both banks of the West Branch of the Susquehanna River for a distance of eight miles has approximately

[2]District Engineer, Pennsylvania Department of Health.

20,000 consumers with an estimated average daily consumption of approximately 2,500,000 gallons of water. The supply is treated with chlorine gas.

The sources of supply are White Deer Creek and Spruce Run. The former has a watershed area of approximately 40 square miles and the latter approximately 13 square miles, almost all of which is owned by the Commonwealth of Pennsylvania and comprises part of a State forest reserve. The water company owns about 700 acres above the intakes, a lumber company a few hundred acres, there are a few private holdings and the remainder is owned by the Commonwealth.

On this watershed practically all of the virgin timber has been removed and to a large extent it is grown over with underbrush and second growth timber. A highway extends along this creek paralleling and occasionally crossing the stream. At some points vehicles are obliged to ford the stream. No lumbering operations are being carried on. The stream is fished during trout season and the shed is traversed also by berry pickers and hunters.

Spruce Run watershed is similar to that found on White Deer Creek. An almost impassable wagon road extends through the shed. All virgin timber has been removed and no lumbering operations are carried on. Fishermen, berry pickers and hunters frequent the shed in season.

On both watersheds numerous club houses and cabins have been built by campers and hunters. There are also tent camps throughout the area. All of the camps presumably are under the supervision of the State Forest Ranger, and campers and hunters remaining over night on the shed are requested to secure a permit from the Department of Forests and Waters. Fishermen and hunters going on the shed for only a single day are not required to secure a permit.

In order that the Department of Forests and Waters and the State Department of Health might work in harmony and understanding in preserving the public health, these departments have jointly set up a procedure for the control of camping on watersheds of streams in State forests from which water supplies are taken for the public without filtration. This procedure is as follows:

The general restrictions shall apply only to streams having more than 50 per cent of the water-shed area above the intake dam within State forests. Water-shed area is to be considered in three zones.

The first zone is to include all territory within the water-shed situated less than 1 mile, measured along the stream, above the intake dam, and no camping privileges are to be granted within this zone.

The second zone is to embrace all territory within the water-shed situated between 1 and 2 miles, measured along the stream, above the intake dam, and no camping privileges are to be granted within this zone unless an approved water-tight privy vault of concrete or stone masonry is provided at the camp in addition to the observance of the standard sanitary restrictions.

The third zone will include all territory within the watershed beyond the 2 mile zone by measurement along the stream above the intake dam. All camps within this zone are to be subject to standard restrictions.

Permanent camps situated within Zone One will be permitted to remain until expiration of existing leases, providing that they comply fully with the instructions set forth herein concerning camps located in the second zone.

Special inspections will be made by the State Department of Health to determine the degree of compliance with sanitary regulations at all camps situated in Zone One during the life of present leases and at all camps situated in Zone Two under existing leases or such camps as are hereafter authorized.

Sanitary considerations for a camp site: Ground should be comparatively level and the soil of an absorptive nature, that is to say, free from outcropping rock ledges and of sand or loam formation.

The tents or cabins should be at a distance of at least 50 feet from the main stream or tributary thereof and so situated that the natural direction for throwing wash and kitchen water would be away from rather than towards the stream.

The privy and garbage pits should likewise be on comparatively level ground and at a distance of at least 100 feet from the stream or tributary, unless a water-tight privy pit of concrete or stone masonry is provided, in which event the distance from the stream should be not less than 50 feet.

If it is intended to take water supply from a spring the camp should be located on lower ground than the spring and other camps further up the stream or slope should not be located within 300 feet of the spring. If a well is dug or driven the same procedure applies as to its location.

Water should not be dipped from a spring but a spring enclosure of wood or masonry should be constructed and provided with an overflow pipe or with a pump from which water can be obtained. The dug or driven well should be protected against surface contamination. Methods of protecting springs and wells against contamination are illustrated in the attached circular.

Permanent camps: All permanent camps shall be situated on comparatively level ground and at a distance of at least 50 feet from the main stream or tributary thereof. A suitable privy shall be provided at each permanent camp and situated at least 100 feet from the main stream or tributary thereof, and below the source of the camp water supply, excepting that if a water-tight vault of concrete or stone masonry is provided, the privy may be located 50 feet from the stream or tributary. Before camp is open the owners shall provide a quantity of hypochlorite of lime (chlorinated lime or "bleach") equivalent to one pound for each week the camp is to be occupied. Contents of privy vaults shall be thoroughly sprinkled with this chemical twice each

week the camp is occupied, using not less than ½ pound of the chemical at each application. After application of the chemical the contents shall be covered with a thin sprinkling of dirt. The contents of the privy vaults shall be removed and buried either promptly upon close of camp for the season or prior to opening the following season. Should vault become filled before close of camp, it shall be emptied promptly. Contents of privy vaults shall be buried at a point not less than 100 feet from a main stream or tributary, immediately upon removal, or they shall be burned.

A suitable hole not less than 18 inches in depth and at least 50 feet from a main stream or tributary shall be provided for garbage and all garbage shall either be thrown in this hole and covered with dirt or shall be burned.

Kitchen or wash water shall not be thrown into a spring or stream or upon the surface of the ground in the immediate neighborhood of a spring or stream.

Temporary camps: All temporary camps shall be situated on comparatively level ground and at a distance of at least 50 feet from a main stream or tributary thereof. At all temporary camps a suitable trench or pit at least 2 feet in depth shall be dug for sewage and such trench or pit shall not be within 100 feet of any main stream or tributary, nor above the source of the camp water supply. Earth from the pit shall be banked on the high side or upon the side away from the stream. Before camp is opened the owners shall provide a quantity of hypochlorite of lime (chlorinated lime or "bleach") equivalent to 1 pound for each week the camp is to be occupied. Contents of privy vaults shall be thoroughly sprinkled with this chemical twice each week the camp is occupied, using not less than ½ pound of the chemical at each application. After application of the chemical the contents shall be covered with a thin sprinkling of dirt. Should privy pit become filled another shall be dug at once. Upon completion of camp, the pit shall be refilled, excess dirt mounded over the top and rammed in place.

Garbage shall be burned or placed in a separate pit similar to that provided for sewage, but shall not be placed in the same pit. Kitchen or wash water shall not be thrown into a spring or stream or upon the surface of the ground in the immediate neighborhood of a spring or stream.

General: Upon close of camps of all classes, all inflammable rubbish and refuse shall be collected and burned.

All tin cans are to be crushed flat and buried.

The camp site is to be left in a neat and cleanly condition.

When campers are away from the camp site, particular care must be taken not to deposit any fecal matter or urine on the ground in the vicinity of any stream or spring.

Failure to observe sanitary regulations will be cause for vacation of the camp and revocation of the permit or lease.

Both the White Deer Creek and Spruce Run watershed are under continual menace due to the presence of habitations on the sheds and the traversing of the shed by travellers, hunters, berry pickers and fishermen. The existing reservoirs do not hold a great quantity of water and consequently a barrier, that might be interposed by

a large storage, is absent. The rugged character of the watersheds and the difficulty of access to certain parts of them, make it difficult to patrol, this being particularly the case during the hunting season when the greatest population occurs on the sheds. Vigilant supervision of the sheds by the water company in coöperation with the resident employees of the Department of Forests and Waters render these sheds reasonably safe, but it does not appear that such supervision can be most effectively exercised during the fishing and camping seasons. The occurrence of habitations, public roadways and the traversing of the watersheds by the public are liable to result in pollution of the water derived therefrom, and the State Department of Health deems it advisable and requires that all water served to the public therefrom must be treated with a chemical germicide. These requirements, with the regulation of sportsmen's camps on watersheds of public water supply systems, as set up jointly by the Department of Health and the Department of Forests and Waters, are considered sufficient protection for these watersheds, where the water is not filtered, but is chlorinated.

WATERSHED PROTECTION, MONTROSE, SUSQUEHANNA COUNTY, PENNSYLVANIA

By I. M. Glace[3]

The Borough of Montrose, in Northeastern Pennsylvania, is supplied with water from a semi-artificial glacial pond having a capacity of 260 million gallons, a superficial area of 45 acres, and a watershed area of $1\frac{1}{2}$ square miles, 80 per cent of which is under cultivation and the remainder wooded. On the shed there are 14 occupied properties, including farm houses, residences, a club house and railway station, 12 of which are provided with cesspools for the disposal of wastes and the other 2 with leaching privy vaults. The shed is crossed by a branch railroad, a trolley line, a State Highway and several township roads. In addition, the lake is utilized as an ice supply and, to a very minor degree for boating and bathing, due to disputed ownership.

Because of the comparative areas of the lake and shed, the flood-absorptive powers of the lake are very great; overflows occur but seldom and then only in small quantities. As a result the storage

[3]District Engineer, Pennsylvania Department of Health.

provided is almost 100 per cent effective, if such inhibiting effects on long-time storage as wind currents, stratification and winter short-circuiting, etc., are neglected. The color content of the water is low and zero turbidities are often recorded at the pump intake which is located not far from the outlet end of the basin.

To prevent, so far as possible, the contamination of this supply various measures have been instituted. The superintendent of the local water company has been deputized by the State Department of Health as a special health officer without pay and with jurisdiction over the watershed only. Monthly inspections of all properties on the shed are made by this superintendent who likewise, through his authority as a State representative, inspects and controls sanitary conditions on and around the lake during the ice cutting season. Coöperation of the street railway company has been secured to prevent nuisances at the station of the company which is a terminal point, and the township supervisors have constructed road drains to by-pass storm water from that portion of the shed nearest the dam and waterworks intake.

The water taken from the lake is disinfected with liquid chlorine and pumped to a distributing reservoir from which it reaches the town by gravity. Daily tests of tap water for residual chlorine are made by the company and weekly bacteriological analyses by a consulting bacteriologist and reports thereon are submitted weekly to the State Department of Health. In addition, samples for bacteriological and chemical examination, in the Laboratories of the Department, are collected by the Bureau of Engineering at irregular intervals and inspections of the chlorine apparatus are made at the same time.

The methods here used for the protection of the watershed are somewhat more intensive than is customary in Northeastern Pennsylvania, except, possibly, on the sheds of the Scranton Gas and Water Company, but they are of value in that they add an additional factor of safety to the major safeguards already provided by long-time storage and disinfection; and again, because they produce a favorable psychological effect on the consumers of the water. Considerable weight must be attached to this latter consideration because it is quite probable that all these protective measures could be abandoned without any serious detrimental effect on the health of the people in Montrose, provided, of course, that the present close and efficient control of the disinfection process be maintained.

It is the opinion of the writer that the comparative value of such intensive watershed work decreases in proportion to the increase in size and extent of the catchment area and quantity of water impounded; that is, where the storage capacity is to be measured in billions of gallons, and the watershed population in hundreds or thousands, scattered over an extensive area, the practical control of all the possible sources of contamination on the shed is not feasible and greater reliance must be placed on disinfection or, more probably, filtration and disinfection. On the other hand where really effective long-time storage is not provided—and very few municipalities in Northeastern Pennsylvania are so favorably situated from this standpoint as is Montrose—watershed protective measures become of greater value, although they can in no instance be considered to take the place of disinfection, which should, of course, be provided for all surface water supplies.

WATERSHED PROTECTION, DUBOIS, CLEARFIELD COUNTY, PENNSYLVANIA

By L. D. Matter[4]

The City of DuBois, located in Clearfield County, derives its water supply from the watersheds of Muzz Run, Anderson Creek and Montgomery Run. The water is stored by means of an impounding basin, formed by an earthen dam across Anderson Creek below the junction of the three above named streams. This reservoir is located about 7 miles southeast of DuBois and has a capacity of about 85 million gallons. The City is supplied by gravity from this reservoir, the average daily consumption amounting to approximately 2 million gallons.

The watersheds of the three streams are contiguous and have a combined area of $24\frac{7}{10}$ square miles. The Muzz Run shed, $1\frac{1}{2}$ square miles in extent, is the smallest of the three, but has the greatest population. A large proportion of this shed is under cultivation and the water from this source is frequently muddy.

The other two watersheds are sparsely inhabited and are for the most part wooded. There is considerable hunting on these sheds with the result that during the hunting season the population is considerably increased.

[4]District Engineer, Pennsylvania Department of Health.

Unfortunately the intake in the reservoir is so located that very little water from Montgomery Run or Anderson Creek can enter. Under existing conditions, therefore, most of the water supplied to DuBois comes from Muzz Run, the least desirable of the three.

In view of the dangerous quality of the water supply taken from the reservoir, as evidenced by investigations of the watersheds and analyses of samples from the system, the State Department of Health in 1920 required the city authorities to install apparatus for the treatment of this water with a chemical germicide as a temporary protective measure. In addition, the city was required to make a study of the situation and report to the State Department of Health on permanent measures for the protection or purification of this supply.

In 1922 the city submitted plans for a proposed water filtration plant and a scheme for increasing the storage capacity of the reservoir. These plans were approved, but owing to the lack of sufficient funds neither project was started.

There were several reasons for this. In the first place, there were numerous complaints in DuBois about inadequate service in the higher portions of the city. Again, a survey made during the summer of 1922, indicated that enormous quantities of water were being lost within the city through leakage. These conditions being before the citizens at all times would naturally claim first consideration. It was, therefore, necessary for the city authorities to devise a program whereby the quality of the water could be improved and thereby comply with the orders of the State Department of Health and at the same time make the necessary improvements to insure adequate service throughout all parts of the city. With this end in view a program was submitted to the State Department of Health for approval in the spring of 1923. That portion of the program providing for the adequacy of service consisted of the construction of a storage reservoir on the highest point in the city and the undertaking of an intensive campaign towards the elimination of leakage in the distributing system.

The second portion of the program concerning the improvement of the quality of the water, which was submitted in lieu of the construction of a filtration plant, included the raising of the water level of the present reservoir approximately 3 feet, thereby increasing the capacity of the same from 85 to 132 million gallons; relocation of the intake to a point where water from the more de-

sirable streams could gain access to the same; the construction of a causeway upon Muzz Run so as to form a settling pool in which sediment carried by the Run would be deposited before the water entered the reservoir proper; the purchase of properties in the vicinity of the reservoir which would be affected by the raising of the water level; the construction of sanitary toilets or tight cesspools at all camps or habitations near any stream tributary to the reservoir; the continuance of the general cleanup program in the area adjacent to the reservoir and the removal of decayed wood and vegetation from the waters edge; the reforesting of the watersheds; and periodical inspection of the watersheds to be followed by a detailed report to the State Department of Health.

In approving this scheme the State Department of Health did not lose sight of the fact that the question of the quality of the of the water to be supplied was of primary importance nor that the city had been previously required to subject the water from this source to filtration. On the other hand, however, the Department had to consider that the city had to deal with the question of adequacy in addition to that of quality and that both problems had to be provided for from limited funds.

In view of these conditions, therefore, the decision of the Department was to the effect that the program should be approved and that the enforcement of the previously issued order requiring the construction of a filtration plant should be temporarily withheld pending the results obtained from the proposed improvements as provided in the above scheme.

WATERSHED PROTECTION, ALTOONA, BLAIR COUNTY, PENNSYLVANIA

By J. Warren Fortenbaugh[5]

One of the most striking and unusual problems in watershed protection is that recently undertaken by the city of Altoona on the drainage area of one of the sources of supply for that city.

The city of Altoona, situated at the foot of the eastern slopes of the Allegheny Mountains, has a present population of approximately 65,000.

The water supply for the city, which is municipally owned, is secured from two surface streams rising on the eastern slopes of

[5] District Engineer, Pennsylvania Department of Health.

the Allegheny Mountains and flowing in a general southeasterly direction toward the city. The streams are impounded in three large reservoirs situated in the Horseshoe Curve. The uppermost has a capacity of 60 million gallons; the next a capacity of 365 million gallons; the lowest a present capacity of 600 million gallons. Arrangements at this latter reservoir are such that ultimately the breast of the dam can be raised to impound 1,600,000,000 gallons. It is thus seen that at present the city has a combined storage capacity of 1,025,000,000, which when the need arises, can be increased to 2,025,000,000 gallons.

The uppermost reservoir is used to supply entirely the higher elevations of the town, while the other ones supply the lower elevations, which include the business district and the Pennsylvania Railroad shops.

It is a significant fact that, although the combined storage period is long as based on either the runoff or the consumption, yet since all of the water must pass through the high level basin, the average retention period here is relatively short being approximately ten days. In addition to the advantages received through natural sedimentation, all of the water supplied to the city is treated at the several intakes with liquid chlorine.

Baker Run is heavily impregnated with acid mine wastes and during recent years the acid content of the water supplied to the city has been relatively high, running from 20 p.p.m. in the low service to 70 p.p.m. in the high service. This acid content has been responsible for attacking the plumbing and piping to an appreciable degree.

The Baker stream to which our attention will be confined, as the other stream is practically neutral as far as the mine drainage problem is concerned, is a typical mountain stream draining an area of 4 square miles above its confluence with the other stream. Ninety per cent of the shed is covered with second growth timber and underbrush, the remainder being cleared and inhabited land. Generally, the valley is narrow and steep, but at its upper end the slopes flatten out and at this point there is situated a small coal mining village, together with several farms. A highway also traverses the upper part of the catchment area. It was estimated at the time of a recent investigation that approximately 800 people lived on the watershed area.

Below the village and somewhat close to the upper end of the stream are the outlets from four mine openings. From weir measure-

ments taken at these mine mouths during the summer of 1921, a total of 375,000 gallons of acid mine water daily reached the stream.

At the expense of the city the municipal authorities decided to mitigate the conditions by bypassing all of this mine drainage, diverting it at the mine mouths and carrying it through terra cotta lines laid with bitulithic joints around the reservoirs, discharging it into the stream below them.

The Department of Health, on the other hand, while it realized the economic value of removing these substances from the water, also was cognizant of the germicidal value of these wastes in a stream having so large a watershed population. To this end it was decided that for the present only the drainage from the two lowermost mines, which were the ones having the highest acid content, might be removed, leaving that from the two upper mines to continue to reach the stream to counteract any chance pollution that might find its way there. This decision was made despite the facts that the city representative makes an inspection of the properties on the shed at stated periods and that the water is disinfected at the several intakes. Should the time arrive when the drainage from the highway and the village can be conducted to the sewer line, which must be extended a considerable distance to intercept it, the Department will then consider the advisability of removing all of the mine drainage from the stream.

While this problem may be somewhat peculiar to Pennsylvania, it does establish the contention that without this protective agency the sedimentation period plus chlorination is not sufficient treatment in the upper reservoir even with the watershed protection undertaken by the city. If all of the drainage from the village and the highway cannot be carried around the reservoirs when it is desired to remove the mine drainage entirely, filtration with chlorination may be necessary.

PROTECTION OF THE WATERSHED OF THE BEAVER RIVER IN PENNSYLVANIA

By Christian L. Siebert[6]

The Beaver River, having a watershed area of 3040 square miles, joins the Ohio River at a point about 24 miles down stream from the

[6] District Engineer, Pennsylvania Department of Health.

city of Pittsburgh. Of the total watershed area 1784 square miles are in Pennsylvania and 1256 square miles are in Ohio.

The Mahoning and Shenango Rivers, having watershed areas respectively of 1099 square miles and 1080 square miles, join at New Castle, Pennsylvania, forming the Beaver River. Practically the entire Mahoning River watershed is in Ohio and almost all of the Shenango River watershed is in Pennsylvania.

The population residing on the watershed of the Beaver River is approximately 560,000, of which about 290,000 reside in Pennsylvania and about 270,000 in Ohio.

It is estimated that 335,000 of the total population of 560,000 contribute sewage to the Beaver River and its tributaries, the sewered population being estimated at about 165,000 in Pennsylvania and 170,000 in Ohio.

Waterworks with filtration plants located at Sharon, New Castle, West Pittsburgh, Ellwood City, Eastvale and New Brighton, all taking water from the Beaver River or its tributaries below the points of discharge of extensive municipal sewer systems, serve a population of approximately 150,000. It is estimated that about 315,000, of the total sewered population of 335,000 contributing to contamination of the Beaver River, discharge sewage above the intakes of waterworks serving the public.

The small streams of relatively good character in the lower Beaver Valley are not of sufficient size to be utilized as the sources of supply of the waterworks serving the population in the vicinity. Neither are the available ground water supplies sufficient to be utilized for public service, except in the instances of a few of the smaller municipalities.

The average minimum rate of flow of the Beaver River at New Brighton, where is located the waterworks intake farthest down stream, is about 150 cubic feet per second, which is equivalent to a dilution factor of only 0.47 cubic feet per second per thousand of the sewage contributing population, whereas the minimum allowable dilution factor ordinarily accepted is 4 or 5 cubic feet per second per thousand of the sewage contributing population, or about ten times the dilution effective in the Beaver River.

The extensive steel and allied industries located in the Youngstown and Sharon districts produce great quantities of industrial wastes which are discharged to the Mahoning River and the Shenango River. The ferrous sulphate liquors from tin-plate works

constitute a large part of the total industrial wastes and these wastes, during periods of relatively low stream flow, effect coagulation of much of the sewage load in the streams, and reduction in the velocity of the streams by a number of small dams accomplishes a very appreciable settling of the coagulated sewage content.

The Commonwealth of Pennsylvania is committed to the construction of a dam on the headwaters of the Shenango River, to be known as the Pymatuning Dam, all of the land required for this purpose having been either purchased or optioned. This dam is intended primarily to regulate floods and to store water for augmenting the extremely low flow of the Shenango River, this stream now being used over so many times for industrial purposes that the water in the river actually reaches a temperature of about 140°F. at Farrell. Increasing the low flow of the Shenango River will incidentally improve dilution of sewage and this factor has been considered in the determinations of the Bureau of Engineering of the Pennsylvania Department of Health concerning sewage treatment on the watershed of the Beaver River.

The modern water filtration plants treating water obtained from the Beaver River and its tributary, the Shenango River, require most skilful operation with constant laboratory control over the application of coagulants, artificial alkalinity and disinfectants and even with such a high degree of scientific supervision and with the most elaborately equipped filtration plants, there are times when it is practically impossible to provide a water that is free of tastes and odors due, as indicated by careful studies, to a combination of industrial wastes and sewage. However, these filtration plants consistently produce water that is free of organisms of the colon group, but the "load" on the filters has been steadily increasing from year to year.

Because of the steadily increasing sewage load in the Beaver and Shenango Rivers and the consequently increasing difficulties in the treatment of water from these sources for public purposes, it has been deemed necessary to adopt a policy looking toward reduction of the sewage load in the streams, but because of the partial reduction of the sewage load by industrial wastes in this particular stream, it has not seemed necessary to require, at this time, refined treatment of sewage discharged to the Beaver River or its tributaries in Pennsylvania, except where local stream conditions demand such treatment, but rather to require first the removal of settleable solids and to have the plans for sewage treatment works

so designed that units for further refinement in treatment may be added when conditions warrant such construction.

There are now 7 municipal sewage treatment works in operation on the Beaver River watershed in Pennsylvania and 11 other municipalities on the watershed have prepared or are preparing to construct such works in the very near future.

The Ohio State Department of Health has been coöperating informally with the Pennsylvania Department of Health toward removal of settleable solids from all sewage discharged from public sewer systems to the Beaver River or any of its tributaries above the intakes of waterworks serving the public and it is the hope that this plan of protection of the Beaver River watershed will be completely realized in the near future.

The reasons for this policy may be summarized as follows:

The communities on the lower Beaver River can be furnished only with water taken from this river, no other adequate sources of supply being available.

Modern water purification works have been able, so far, to produce consistently safe water for public use from the Beaver River, even though tastes and odors are often present and the increasing "load" on the filters is noticeable.

The necessity for protection of the watershed is evident. The elimination of all minor rural pollutions on the entire watershed would be of no practical advantage since the bulk of the sewage contamination is from public sewer systems. Refined treatment of sewage from public sewer systems would not seem justified, since industrial wastes discharged to the stream do effect some reduction of the sewage load and since these industrial wastes are so great in quantity that, even though refined sewage treatment were accomplished, the river would still not be fit for use as a source of public water supply without the most effective water purification.

The elimination of the discharge of industrial wastes to the Beaver River and its tributaries is economically impracticable, although routine investigation and control measures are effective in preventing the discharge of the more objectionable industrial wastes to the Beaver River and its tributaries.

Hence the policy: The removal of settleable solids from the sewage discharged from public sewer systems to the Beaver River or its tributaries above the intakes of waterworks serving the public, and this to be accomplished in such a manner that more refined methods of sewage treatment may be economically adopted when such additional treatment is justified.

PROGRESS REPORT ON AGENCIES FOR THE CONTROL OF POLLUTION BY INDUSTRIAL WASTES

By Committee No. 6 on Industrial Wastes in Relation to Water Supply[1]

Your Committee on Industrial Wastes in Relation to Water Supply presents the following Progress Report on Agencies for the Control of Pollution by Industrial Wastes.

In our Progress Report of 1922, which was published in a modified form in the Journal of the Association for May, 1923, we presented information showing that more than 250 water supplies widely distributed through the United States and Canada have been injuriously affected by at least 20 different kinds of industrial wastes. The solution of water supply problems due to industrial wastes was discussed, and the need of more adequate control by state boards of health, the United States Public Health Service or other agencies, was emphasized. The present report deals with the agencies in this country and abroad, which have to do with the control of pollution by industrial wastes.

ASPECTS OF INDUSTRIAL WASTES POLLUTION

The broad subject of pollution of waters by industrial wastes has several important aspects among which may be mentioned public health, particularly in relation to domestic water supply; public comfort, especially as regards effect on boating and bathing and conditions objectionable to sight and smell; commercial aspects, particularly as regards effect on fish and other animal life, and the use of water for industrial process purposes; and navigation, especially as regards deposits causing obstruction to shipping and the presence of objectionable substances such as acids, causing damage to vessels, and oil creating a fire hazard at the docks. Obviously industrial wastes pollution has an influence on the functions of several governmental departments, both state and national.

[1] Prepared under the direction of the Council.

STATE AUTHORITIES

Cities and towns have the responsibility of abating local nuisances and installing sewerage systems and sewage treatment works, but in matters of stream pollution the control is very largely in the hands of state authorities.

State Boards of Health. The control of stream pollution in the United States has been vested very largely in the state boards of health, although the replies to the questionnaire sent out by your Committee showed only five states where the authority is ample in all respects, and nearly all reported that enforcement of the laws is materially hampered by insufficient appropriation for adequate field and laboratory forces.

State Commissions on Fisheries. The control of stream pollution with respect to fish life has been exercised to some extent by state commissions on fisheries, or other boards having similar duties.

State Boards of Conservation. In some states the control of stream pollution is placed in the hands of state boards of conservation, generally with respect to effect on fish life. For example, the Conservation Commission of New York has a Bureau of Prevention of Stream Pollution, which has recently (1923) made a report on "Investigation of Pollution of Streams," authorized by the state legislature. It is interesting to note that this report recommends the establishment of a "Conservancy Commission" with general and wide powers of regulation and control of the uses of streams as affecting the quality of the water.

Rhode Island Board of Purification of Waters. In some states special boards have been created for the control of pollution of waters. The Rhode Island Board of Purification of Waters is an example of such a board. This board was created by Chapter 1914 of the Public Laws passed by the State Legislature in 1920. By Section 3 of this Act the Board is authorized and directed to regulate or prohibit the pollution of waters of the State in accordance with the provisions of the Act. The members of the Board are appointed by the Governor, with the advice and consent of the Senate, the term of office being one year. The Board makes annual reports to the Governor.

Industrial Wastes Board of Connecticut. The legislature of Connecticut in 1917 made provision for an Advisory Board to aid and assist the Department of Health in the matter of needed sewer-

age systems and refuse disposal works. Section 2562 of the Act provides as follows:

> Sec. 2562. *Assistance in Carrying out Preceding Section.* The State Department of Health, acting with five persons appointed by the governor at least two of whom shall be of recognized experience in sanitation, and at least two of whom shall be manufacturers, is authorized to make such investigations and employ such expert assistance as may be necessary to enable it to carry out the provisions of Section 2561, concerning pollution of the waters of this state. The persons so appointed shall serve without compensation. For the purposes of this section the sum of twenty-five thousand dollars is appropriated out of any money in the treasury not otherwise appropriated.

This Board adopted the title "Industrial Wastes Board," and decided to take up only the problems relating to conditions resulting from the discharge of industrial wastes, and to refer all other matters back to the State Department of Health, for disposition. The Board made reports in 1918 and 1920. It is not now in existence, but there is agitation going on looking to its renewal.

Pennsylvania Sanitary Water Board. The Sanitary Water Board of Pennsylvania was created by the general administrative code enacted by the 1923 Legislature for the purpose of coördinating the duties and authority of various branches of the State Government having similar purposes.

The Board consists of the Secretary of Health, who is designated as Chairman; the Secretary of Forests and Waters; the Attorney General; the Commissioner of Fisheries, and the Chairman of the Public Service Commission, and is given authority to exercise all the powers vested in the several departments relating to the pollution of streams, and which were formerly administered independently by these various state departments.

The basic legislation upon which the principal actions of the Board must rest are two in number, the first, known as the "Purity of Waters Act" enacted in 1905, to control sewage pollution of streams, for the protection of the public health, and previously administered by the Department of Health, and the second, a section of the Fisheries Code of 1917, prohibiting the discharge of substances destructive to fish. Other laws of lesser import, formerly administered by various branches of the State Government are also placed under the jurisdiction of this new Board.

The Act also provides for a study and report on methods of preventing stream pollution detrimental to public health or to animals,

fish or aquatic life, or to the use of waters for recreational purposes, and applies to all streams whether within or touching the boundaries of the State.

The Board has adopted resolutions establishing a number of fundamental policies, such as approval of former policies of the Department of Health relative to sewage discharge, the joint agreement between the States of Pennsylvania and New Jersey relative to the pollution of the Delaware River, and the joint agreement of the Departments of Health and Forests regarding camping on watersheds from which public water supplies are taken.

An important resolution which should eventually be of great value in control of stream pollution was adopted on August 8, 1923, and divides all streams of the State into three classes.

Class A streams are those in their natural state unpolluted by any artificial source, and generally fit for domestic water supply after chlorination. For this class of streams it is required that any sewage or industrial wastes originating on the watershed shall be treated to such a degree that the effluent shall be practically free from suspended matter, non-putrescent and disinfected, and that recreational use shall not be sanctioned within prejudicial influence of waterworks intakes.

Class B streams are those in which pollution is more or less existent at the present time, and where the extent of regulation, control or elimination is to be determined by consideration of the present and probable future uses of the stream, practicability of measures for abatement of pollution, and the general need for protection of the public health, animal and aquatic life, and use of the stream for recreational purposes. For this class it is proposed to determine a fixed policy for each particular stream or portion thereof after consideration of the general interests of the public and requirements of the particular case.

Class C streams are those which are now so polluted that they cannot be used as sources of public water supply, will not support fish life, and are not used for recreational purposes, and which from the standpoint of public interest, it is not necessary, economical or advisable to attempt to restore to a cleanly condition. In this class of streams, discharge of sewage and industrial wastes is permitted, provided such discharge will not create a public nuisance or menace to health.

Since its creation engineers of the Board have been correlating information in possession of the State Departments and performing additional field work to classify certain streams where there seems to be particular need of prompt action. Permits issued by the Board for the discharge of sewage or industrial wastes, or which stipulate the degree of treatment required, are in conformity with

the policies announced for respective streams, or may be taken by the public as an indication of the policy which may be set up for the particular type of stream under consideration.

In order that there may be a minimum of delay in functioning, the law delegates authority to the Department of Health to issue orders between sessions of the Board, and to take such action within the powers of the Board as the circumstances may require, but stipulates that any such order or action is subject to review by the Board at its next session.

It does not appear that this Board has great authority above that formerly possessed by individual departments, but it seems to be a forward step in that a maximum of value can now be derived through uniform administration of the numerous excellent laws upon the statute books.

"The Powers, Duties and Policies of the Sanitary Water Board of the Commonwealth" is the title of a paper by W. L. Stevenson, Chief Engineer of the Pennsylvania Department of Health, presented at the Conference on Pollution of Streams, held in Philadelphia, October 16, 1923, and published in *Engineers and Engineering*, volume XL (November, 1923), page 281.

FEDERAL AUTHORITIES

Industrial wastes pollution is a matter of concern to several departments of the Federal government. This fact is well illustrated by the introduction in the present session of Congress of several bills relating to oil pollution, some of which are very similar, except with respect to administration, the War Department, the Department of Commerce and the Department of the Interior, being named in different bills. Furthermore, a representative of the Surgeon General of the United States Public Health Service, which is under the jurisdiction of the Treasury Department, stated at the hearings on these bills[2] that oil pollution of coastal waters has an indirect effect on health, in which the Public Health Service is interested.

United States Public Health Service. According to the statement of Dr. A. M. Stimson, Assistant Surgeon General,[2] the United

[2] Hearings on Pollution of Navigable Waters, before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, First Session, January 23, 24, 25, 29 and 30, 1924, pp. 286-288.

States Public Health Service has authority to investigate the pollution of streams as affecting the public health, but has no administrative or control authority. During the past ten or more years the Public Health Service has made numerous investigations with respect to stream pollution, including experiments in the treatment of several industrial wastes. At the Philadelphia conference on Pollution of Streams, Dr. W. H. Frost, Surgeon of the United States Public Health Service presented a very interesting paper on "The Correlation of Sources of Pollution," published in *Engineers and Engineering*, volume XL, December, 1923, pp. 305 to 308.

Department of Commerce. The Department of Commerce is interested in pollution as respects fish life, through its Bureau of Fisheries, and as related to shipping, through its Bureau of Navigation. At the recent hearings before the Committee on Rivers and Harbors, Lewis Radcliffe, Deputy Commissioner of Fisheries,[3] presented information regarding the effect of oil pollution on fish life. With reference to the control of oil pollution Secretary Hoover stated[4] "that it is pretty certain that the law could be administered by the Department of Commerce through existing agencies in the Bureau of Navigation and in the Steamboat Inspection Service, with the addition of practically no officials and at only very minor expense."

Department of the Interior. The Bureau of Mines, of the Department of the Interior, has made an extensive investigation of petroleum oil pollution and has issued a report on the subject. Dr. F. W. Lane, Petroleum Chemist of the Bureau, discussed this subject at the recent hearings before the Committee on Rivers and Harbors.[5] He stated that the Bureau of Mines has dealt only with pollution due to petroleum oil and that the investigations were confined to the coast.

War Department. The War Department has jurisdiction over stream pollution from the point of view of navigation. At the Philadelphia Conference on Pollution of Streams, Colonel F. C. Boggs of the Corps of Engineers, presented a very interesting paper on "Stream Pollution as Affecting Navigation[6] in which the laws bearing on the subject are explained. He divides industrial wastes

[3] Ibid., pp. 24–27.
[4] Ibid., p. 10.
[5] Ibid., pp. 17–23 and 218–221.
[6] *Engineers and Engineering*, vol. XL, February, 1924, pp. 40–46

as related to navigation, into two general classes,—first, solids, which may actually impede vessels or which by their deposition in navigable channels may form obstructions; and second, semi-solids, or liquids, which may be injurious to navigation interests either by their chemical attack on shipping facilities or by their menace to such facilities from some other cause, as for example fire. The administration of the laws lies with the Secretary of War and Chief of Engineers, through the Division Engineer and District Engineer of the district in which the pollution occurs. At the recent hearings on pollution of navigable waters Major General Lansing H. Beach, Chief of Engineers[7] presented information regarding pollution particularly with respect to acid wastes.

Provision for Control of Pollution in New York Harbor. Although the control of pollution of navigable waters is vested in the War Department, there is on the statute books the Act of June 29, 1888, amended by the Act of August 18, 1894, for the prevention of pollution in New York Harbor, which is independent of the War Department. This Act deals with pollution not only by the waste matters referred to in the general River and Harbor Act, but also with respect to oil and oil wastes, and under this Act the supervision of New York Harbor is placed in the hands of the Supervisor of the Port of New York and a naval officer is detailed for this particular work, and the expenses of this supervision are covered by special congressional appropriations. The present Supervisor of New York Harbor, Capt. J. C. Freemont, United States Navy, made a statement regarding the oil pollution situation at the recent hearings before the Committee on Rivers and Harbors.[8]

JOINT UNDERTAKINGS ALONG SANITARY LINES, WITHIN SEPARATE STATES

The multiplicity of interests affected by industrial wastes pollution demonstrates the need for joint undertakings for the solution of problems resulting therefrom. There has been a considerable number of such joint undertakings within individual states in this country.

[7] Hearings on Pollution of Navigable Waters, before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, First Session, January 23, 24, 25, 29 and 30, 1924, pp. 271–284.

[8] Ibid., pp. 37–40.

Provision for Sanitary Districts. In order to facilitate common interests in sanitary matters such as water supply and sewage disposal, laws making provision for sanitary districts comprising two or more municipalities have been passed in several states. Among these may be cited the laws making provision for Sanitary districts in the State of Indiana. The Act (Chapter 307 of the General Laws of Indiana, 1913) as amended (Chapter 11 of the General Laws, 1919) provides that two or more incorporated municipalities in any one country may form a sanitary district upon petition of 500 legal voters and a majority vote passed by each municipality in an election held for the purpose. The Act provides for the construction of sewerage works and works for the disposal of garbage and refuse, the issuing of bonds and the levying of taxes. The issuing of bonds is limited to 2 per cent of the valuation, and the rate of interest is not to exceed 5 per cent. The tax levy is not to exceed 0.25 per cent of the valuation of the taxable property. The administration of the law is placed in the hands of 5 trustees appointed by the Judge of the Circuit Court of the county in which the district is located, and receiving a salary of $500 each.

A paper on "Organization of Metropolitan Districts," by Langdon Pearse, was presented before the American Society for Municipal Improvements in 1921, and was published in the Proceedings of the Society for that year. A few examples of such organizations are described below.

Metropolitan District Commission in Massachusetts. One of the earliest sanitary district organizations was the Metropolitan Sewerage Board in Massachusetts, serving Boston and the Metropolitan area thereabout, formed in 1889. In 1895 a Metropolitan Water Board was formed, and in 1901 these two boards were consolidated into the Metropolitan Water and Sewerage Board. In 1919 provision was made for the formation of the Metropolitan District Commission (Chapter 350, General Acts of 1919), whereby the Metropolitan Water and Sewerage Board and the Metropolitan Park Commission were consolidated.

The Metropolitan District Commission consists of one commissioner and four associate commissioners, appointed by the Governor, with the advice and consent of the Council, for a term of five years. The Commissioner receives an annual salary not to exceed $6000, and the associate commissioners not over $1000 each. The Commission is organized with Water, Sewerage and Park divisions, each having the necessary engineering, clerical and police force. The districts served by these divisions are not coextensive. Although administered by the same board, each division has a separate organization. The expenses of the maintenance of the divisions are kept separately, and the

salaries of the commissioners and general office expenses are apportioned among the divisions. The appropriations are made by the State Legislature, and the moneys are handled by the State Treasurer, who assesses the expense against the various cities and towns in accordance with the terms of the legislative act.

The Sanitary District of Chicago. The Sanitary District of Chicago is described by Langdon Pearse, Chief Engineer of the District, as follows:

"Operative under the Act of May 29, 1889. The original act of May 29, 1889, has been amended in various years, both to extend the powers of the District and to cure various defects found, as well as to provide for annexation of additional areas. While originally drawn as a general act, it has been adopted alone by the Sanitary District of Chicago. Powers are granted by the charter to build channels, drains and docks, dispose of water power, and by the most recent amendment specific power to construct intercepting sewers, pumping stations and sewage treatment works. The district at present comprises some 45 municipalities, including the city of Chicago. For the purpose of administration, a board of nine members is provided, three of whom are elected every two years, and one of whom is chosen by the Board to act as presiding officer. The funds for the work are provided by the issuing of bonds, in amounts not to exceed 3 per cent of the assessed valuation. For operating expenses, payment of interest and the like, provision is made for a taxing power not to exceed $\frac{2}{3}$ per cent of the assessed valuation. The most recent amendment provides for a minimum levy of 1.2 mills on the dollar. The area served at present is 395.51 square miles, and includes all of Chicago and 45 incorporated cities and villages." (*Proc. of the Amer. Soc. for Munic. Improvements*, 1921 Convention, pp. 109–125.)

Passaic Valley Sewerage Commission. Chapter 10 of the New Jersey Laws of 1907 provides for purification of the waters of the Passaic River within the Passaic Valley Sewerage District from the Great Falls in Paterson to the mouth of the Passaic River in Newark Bay. The Passaic Valley Sewerage Commission of five members, appointed by the Governor, each for a term of five years, has complete jurisdiction over this project so far as the state is concerned.

This act fixes a date when every municipality, corporation and individual is prohibited from discharging polluting matter into the Passaic River within the limits of the district. The Commission is authorized to institute suits at law or in equity to enforce this provision and the Court of Chancery is also vested with special jurisdiction in respect to such enforcement. Municipalities may provide separate adequate purification arrangements or they may enter into a joint undertaking as provided for in the Act. The Commission has authority to contract with municipalities for the construction of intercepting sewers and disposal works for the disposal of polluting matters including not more than 10 per cent of the factory wastes excluding gas works wastes and other substances which may injuriously affect the integrity of the sewers. Such contracts with municipalities stipulate a capacity which each municipality is to have in the joint works but a municipality may contract for more than its prorated share by meeting the expense of any such requisition. The construction cost is to be apportioned among the contracting

municipalities in proportion to their taxable property. Funds in addition to those provided in the initial contract and required for the works as a whole, are procurable only through supplementary contracts between the Commission and all contracting municipalities. Under the State Constitution the state cannot issue bonds for such an undertaking. The contracting municipalities are authorized to issue bonds for this purpose up to 5 per cent of their tax ratables in addition to the established bonding limit for other purposes.

The cost of operation and maintenance of these works, expected to go in service in the early summer of 1924, is to be raised by the contracting municipalities by taxation, and prorated according to the volume of sewage and wastes contributed by each.

Joint Meeting of the Inhabitants of the City of Plainfield, the Borough of North Plainfield and the Borough of Dunellen. Chapter 112 of the New Jersey Laws of 1910 authorizes any two or more municipalities in the state to jointly provide and operate outlet sewers and sewage disposal plants. This is the basis on which Madison and Chatham and also Plainfield, North Plainfield and Dunellen have proceeded. The sewage of the three last named places is treated at Green Brook Park. This act provides that municipalities desiring to establish joint works shall first prepare an adequate preliminary report of the undertaking with estimates of cost of construction and operation. This report, made at joint expense, must be acceptable to the authorities of each municipality and to the State Board of Health. The inhabitants of the municipalities must vote on means of financing the project by assessment or the issue of bonds as may be decided upon.

After an affirmative vote of the municipalities there is set up a "Joint Meeting" composed of members of the municipal government of the interested parties and such other members as may be respectively decided upon. This Joint Meeting thenceforth proceeds with officers and committees and employees in substantially the same manner as would individual municipalities. Each municipality on request from the Joint Meeting provides its established share of the cost of construction. Expense of operation and maintenance is in accordance with agreements in the contract between the municipalities and in some instances is based on the respective volumes of sewage flow and in other instances on the number of sewer connections. Joint Meetings authorize and approve a budget of expense, the contributions to which are generally made to the Joint Meeting for disbursement through its officers.

Joint Undertakings in California. In California, Pasadena, South Pasadena and Alhambra for a great many years have been disposing of their sewages by a mutual contract. They are now constructing an activated sludge plant on the same basis, each city having voted bonds for an agreed amount, and arrangement is made whereby Pasadena, for certain payment, assumes all responsibility for the treatment. A similar working agreement exists between the towns of Santa Ana, Anaheim, Orange and Fullerton. In this case the work is the construction of a long outfall to the ocean and a screening plant. Santa Ana assumes the responsibility for the operation of the plant.

Los Angeles is entering into contracts with cities round about for carrying their sewage to the ocean and screening it. The last legislature passed a

bill called the "County Sanitation District Act" which has for its express purpose the building of trunk line sewers to serve several cities and even unincorporated territory, but the bill also provides that such a District may by arrangement take over all or part of the local sewer system and treatment works. One District has been formed in the southern part of the state, called the South Coast Metropolitan Sewer District, comprising Manhattan, Hermosa Beach, Redondo Beach and Palos Verde. Another District is being agitated, called the Central Metropolitan District, which would provide for Compton, Watts, Whittier, and a great many still smaller communities. This act has not been submitted to the Courts, but undoubtedly it will be reviewed by them before any of the Districts finally complete their plans.

There is also another act called the "City Boundary Extension Act" passed by the last legislature, which enables several cities and county territory to construct sewage works, using one of the favored improvements acts. This act, however, does not provide for maintenance and until this is provided, the item must be covered by mutual contribution of the cities and territory affected.

EUROPEAN BOARDS FOR THE CONTROL OF STREAM POLLUTON

There appears to be no general provision in this country for joint undertakings with respect to the control of stream pollution by two or more states, although there have been mutual agreements between different states, notably that of Pennsylvania and New Jersey, which provides a uniform policy as to the degree of treatment of sewage, required prior to discharge into Delaware River, adopted by the departments of health of the two states in 1922.

In Great Britain and in Germany there are a number of boards having jurisdiction over whole watersheds. These boards are referred to in a paper on "Government Control of Pollution," by C. A. Emerson, presented at the Philadelphia Convention on Pollution of Streams and published in *Engineers and Engineering*, volume XLI, January, 1924, pp. 11–13. Additional information is given by George W. Fuller in his discussion of this paper.

Provision for Rivers Boards in Great Britain. From the Interim Report of the Royal Commission on Sewage Disposal, 1901, volume I, page xi, it appears that, on account of the fact that the Rivers Pollution Prevention Act, of 1876 had not resulted in the general purification of the rivers, due largely to the reluctance of each local authority to put the Act in force, without assurance that other local authorities on the stream would do likewise, but partly to the difficulty in proving that the pollution complained of was the result of discharge within that particular district, a Local Government

Act was passed in 1888, authorizing the county councils of England and Wales and Scotland to enforce the provisions of the Rivers Pollution Prevention Act, in relation to the portions of any stream within their counties, and specifying that "The Local Government Board by Provisional Order made on the application of the Council of any of the counties concerned, may constitute a Joint Committee or other body, representing all the administrative counties, through or by which a river or any specified portion of a river or any tributary thereof passes, and may confer on such committee or body all the powers of a sanitary authority, under the Rivers Pollution Prevention Act, 1876, or such of them as may be specified in the Order." Under this act three rivers were constituted:

The Mersey and Irwell Joint Committee
The Ribble Joint Committee
The West Riding of Yorkshire Rivers Board

These boards comprise from 20 to 30 men elected by the councils of the component municipalities, from among their own membership. Representation on the Board is proportionate to the size of each municipality, and operating expenses are provided from funds collected from the various municipalities. The actions of these boards, in carrying out the general pollution laws, are to a large extent independent of the Ministry of Health in London, which was recently formed to take over the functions of the Local Government Board; but in the case of such matters as bond issues or legal action against a manufacturer the consent of the Ministry of Health must previously be obtained.

The Mersey and Irwell Joint Committee. The Mersey and Irwell Joint Committee was formed in 1891 and has jurisdiction over a portion of the watersheds of the Mersey and Irwell Rivers, including the county boroughs of Bolton, Bury, Manchester, Oldham, Rochdale, Salford and Stockport. According to the testimony of R. A. Tatton, before the Royal Commission on Sewage Disposal, Interim Report, 1902, volume II, the Mersey and Irwell rivers were badly polluted and the construction of the Manchester Ship Canal, in which the waters of Irwell River were impounded, made some action necessary. In 1889 a conference of sanitary authorities was held and an appeal made to the county councils of Lancashire and Cheshire, which in turn applied to the Local Government Board. The outcome was a provisional order of the Local Government Board, constituting the Joint Committee of the rivers Mersey and Irwell.

The first meeting was held at Manchester, October 5, 1891. The early work was confined to prevention of pollution by solids. A survey was made of sources of sewage and trade wastes pollution. On December 7, 1891, a bill for further powers was introduced, which was supported by the manufacturers, who felt that they would benefit by improved water courses. In 1892 the Committee applied for still further power, and this was granted. The Committee decided to adopt no fixed standard of pollution.

The Ribble Joint Committee. The Ribble Joint Committee was formed in 1891, and has jurisdiction over portions of the watersheds of the River Ribble, and certain other streams, including the county boroughs of Blackburn, Burnley, Preston and Wigan. According to the testimony of William Naylor, before the Royal Commission, Interim Report, volume II, 1902, the Ribble Joint Committee held meetings monthly, presenting a report each month and annual reports in 1897 and 1898.

In 1893 Mr. Naylor presented to the Committee a special report, which was followed by a conference with manufacturers, with respect to the treatment works desirable for them to install. Agreements were drawn up with the different trades, but in the case of the paper trade no general agreement was arrived at and the Committee dealt with each case separately.

The West Riding of Yorkshire Rivers Board. The West Riding of Yorkshire Rivers Board was formed in 1893, and has jurisdiction over the rivers in the county boroughs of Bradford, Halifax, Huddersfield, Leeds and Sheffield, which constitute an important industrial district. According to the testimony of Trevor Edwards, before the Royal Commission, Interim Report, volume II, 1902, this Committee consists of 30 members elected from 6 counties. In addition to the powers of a sanitary authority under the Rivers Pollution Prevention Acts, the Board has additional powers under "The West Riding of Yorkshire Rivers Act of 1894." The magistrates are the tribunal under this act.

Advantages of Rivers Boards. The Royal Commission, in its third report, 1903, states that these rivers boards are of much greater value for the protection of rivers and streams than the separate councils acting independently, and that, although some of those against whom action has been taken by these boards, have complained, as might be expected, generally speaking both the local authorities and the manufacturers recognize that in this way ef-

fective action is taken for the improvement of the rivers in their districts. The evidence before the Royal Commission on Sewage Disposal shows that these boards have accomplished much useful work in cleaning up the rivers.

We are informed that about the middle of April, 1923, a conference was held, respecting the formation of a new rivers board for the Valley of the Trent, but we have not yet learned whether such a board has been formed.

Other Boards in Great Britain. Other boards having similar functions have been created by special acts. The Thames Conservancy Board has control of the upper reaches of the River Thames, from which the London Water supply is taken. The tidal portion of the river, below Teddington Weir, is under the jurisdiction of the Port of London Authority.

Emscher District in Germany.[9] In Germany there are various river or drainage districts, of which the Emscher District in the industrial area of western Germany is a noteworthy example. In 1902, following an order by the Prussian government, requiring the construction of sewerage works in the district, a number of municipalities and large industries in the district, formed an association and employed experts to determine what action should be taken. The Chief Engineer's report, completed in 1904, described existing conditions, outlined a plan for improvement, and suggested the passage of a law appointing a Board of Control for the district, with very broad powers, including authority first, to compel cities and towns to construct and maintain suitable sewerage systems for the removal of house sewage and liquid manufacturing wastes, preliminary treatment of the latter being required where necessary; second, to design, construct, maintain and operate, sewage disposal works to be used by two or more municipalities, and to deepen, enlarge, or change the course of the main stream and such tributaries as might require changes to insure satisfactory drainage of the entire area.

In 1906 the Prussian government passed a law granting substantially the authority requested to a Board made up of more than 100 members, representing the state, county, city, farm, mine, and industrial interests.

The Emscher District is not coincident with any political division, but includes the entire drainage area of the Emscher River, repre-

[9] Information from Article by Charles M. Saville in Eng. News, December 1, 1910.

senting an area of approximately 308 square miles. The Board, or General Assembly, meets usually once a year, the actual work being carried on by a Board of Directors, 10 in number, The law requires that at least 3 of the directors must be representatives of the state. The others are chosen from among the mayors of the larger cities, and officials of the more important industries in the district. Another body, acting as a Board of Appeals, is also elected by the General Assembly, and the law requires that a certain number of the members be representatives of the state. The Board of Directors employs an engineering force, and has general supervision over the design, construction, and operation, of the engineering works. It submits a budget annually to the General Assembly, and upon approval, raises money by the issue of bonds, and it has charge of all expenditures. The cost of improvements is charged against the cities, land, mine, and industrial interests, the assessments being determined each year by the Board of Directors on the basis of responsibility for the objectionable conditions to be eliminated, and the improvements derived. In case the assessments appear to be unjust, the matter must be submitted to the Board of Appeals, whose decision is final. The General Assembly, under the law, may exercise the right of eminent domain, and take any land necessary for carrying out its work, disagreements concerning the value of the property taken being settled in the courts.

INTERNATIONAL ASPECTS

The problem of pollution of waters has its international aspects. *International Joint Commission of the United States and Canada:*

Under the terms of Article IX of the treaty of January 11, 1909, between the United States and Great Britain, the Governments of the United States and of the Dominion of Canada jointly referred to the International Joint Commission for examination and report, with such conclusions and recommendations as might seem appropriate, the following questions:

(1) To what extent and by what causes and in what localities have the boundary waters between the United States and Canada been polluted so as to be injurious to the public health and unfit for domestic or other uses?

(2) In what way or manner, whether by the construction and operation of suitable drainage canals or plants at convenient points or otherwise, is it possible and advisable to remedy or prevent the pollution of these waters, and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses be best secured and

maintained in order to insure the adequate protection and development of all interests involved on both sides of the boundary, and to fulfil the obligations undertaken in Article IV of the waterways treaty of January 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other? (Progress Report of the International Joint Commission, January 16, 1914, p. 3.)

This Commission, with the aid of sanitary experts, made extensive investigations. A voluminous progress report was presented on January 16, 1914, and a Final Report, with conclusions and recommendations, on August 12, 1918. The final recommendation was as follows:

In order to remedy and prevent the pollution of boundary waters and to render them sanitary and suitable for domestic purposes and other uses, and to secure adequate protection and development of all interests involved on both sides of the boundary, and to fulfill the obligations undertaken in Article IV of the treaty, it is advisable to confer upon the International Joint Commission ample jurisdiction to regulate and prohibit this pollution of boundary waters and waters crossing the boundary. (Final Report of the International Joint Commission, p. 52.)

So far as we are informed this Joint Commission is still in existence.

Conference of Maritime Nations, on Oil Pollution. By a joint resolution of Congress, approved July 1, 1922, the President was "authorized and requested to call a conference of maritime nations with a view to the adoption of effective means for the prevention of pollution of navigable waters, by oil-burning and oil-carrying steamers, by the dumping into such waters of oil waste, fuel-oil, oil sludge, oil slop, tar residue and water ballast." Following the passage of this resolution a Joint Committee of the Department of Commerce, the Department of the Interior and other departments, was formed, to study the question. Secretary Hoover stated at the hearings before the Committee on Rivers and Harbors[10] that there has been a good deal of discussion with the British, regarding the preliminaries of such a conference, and that the International Conference will probably be held at an early date.

[10] Hearings on Pollution of Navigable Waters, before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, First Session, January 23, 24, 25, 29 and 30, 1924, p. 11.

CONFERENCES ON INDUSTRIAL WASTES POLLUTION

The pollution of waters by industrial wastes has become very acute in different parts of this country and ways and means must be found for solving the problems created thereby. Such problems can be solved only by coöperative effort of all interested parties. Several important conferences on industrial wastes pollution have been held recently which should be referred to in this report.

Philadelphia Conference on Pollution of Streams. Under the auspices of the Engineers' Club of Philadelphia, a conference on Pollution of Streams Especially with Reference to Pollution due to Industrial Wastes, was held in Philadelphia on October 16, 1923. To this conference were invited representatives from National, State and City Governments, from various societies and from the industries themselves. Papers presenting different aspects of the subject were read and discussed. These papers which are being published in *Engineers and Engineering*, the journal of the Philadelphia Engineers' Club, have constituted one of the sources of information for this report. The work of your Committee on Industrial Wastes in Relation to Water Supply was described in a paper by the Chairman.

Conferences on Phenol Wastes. The serious and widespread troubles from tastes and odors imparted to water supplies by the so-called phenol wastes from gas and by-product coke manufacturing, led the Surgeon-General of the United States Public Health Service to call together, for a conference on this subject, the various representatives of the States and Health Organizations, where complaints of this kind of pollution have originated. The final result of this conference was the adoption of a resolution requesting the United States Public Health Service to further investigate this problem with respect to its public health aspects, and the Bureau of Mines to investigate it in its industrial aspects, that is, particularly in regard to practical methods of eliminating or treating the wastes at their sources.

Surgeon W. H. Frost of the United States Public Health Service has been in communication with the Chairman of your Committee on Industrial Wastes in Relation to Water Supply and has been furnished the detailed information on this subject collected by the Committee. Mr. H. R. Crohurst, Sanitary Engineer, has been assigned to make the investigation for the Public Health Service,

and, at Dr. Frost's request, the Chairman of your Committee held a conference with Mr. Crohurst in relation to the scope and methods of his investigations.

In a statement made at the Hearings on the Pollution of Navigable Waters, before the Committee on Rivers and Harbors in January, 1924, Dr. A. M. Stimson, Assistant Surgeon General of the United States Public Health Service[11] refers to a second conference held that week at which representatives of all of the Ohio River states with the exception of Indiana and Illinois were present. He states that in the absence of existing legislation of a Federal nature, the health officials and engineers attached to the Health Departments have organized themselves into an informal committee for the purpose of securing what can be done locally by interstate agreement, believing that they should exhaust the possibilities of such agreement and learn by experience what the methods of prevention are before calling for specific aid in the way of Federal Legislation.

A permanent organization has been effected with Dr. Monger of Ohio, President, and Mr. Tisdale, of West Virginia, as Secretary. The objects of this organization, as expressed in the Resolutions adopted, include the establishing by the states interested of a standard policy of administrative control and uniform policy of action to secure correction of the damage to public water supplies caused by coke plants and other industries producing taste-causing wastes.

National Coast Antipollution League. Because of the serious and widespread pollution of coastal waters of the United States, the National Coast Antipollution League was formed in 1922. David M. Neuberger, President of the League, stated at the hearings on the Pollution of Navigable Waters before the Committee on Rivers and Harbors,[12] that the Antipollution League came into existence as a result of an interstate committee for the prevention of pollution of the coastal waters of New York and New Jersey, and of a call which was made by the State League of New Jersey Municipalities, upon the Atlantic Coast municipalities of the United States for a conference and formation of a permanent body to be organized to obtain the enactment of Federal and State Laws to prevent further pollution of coastal and inland waters.

[11] Ibid., pp. 286–288.
[12] Ibid., pp. 56–65.

A Conference on Pollution called by the League, was held at Atlantic City on October 2 and 3, 1923, and a Committee was appointed to confer upon the proposed legislation. The League has been active in the legislation now before Congress.

LEGISLATION

The tendency of legislation with respect to pollution of waters by industrial wastes, is shown by the bills introduced in the present session of Congress.

S-42. Among the bills introduced in the Senate, and considered at a hearing before a sub-committee of the Committee on Commerce, January 9, 1924, S-42 which is the most drastic, makes it unlawful to discharge from any ship or from any land plant, oil in any form, or any refuse matter of any kind other than ordinary sewage, into any navigable water of the United States, or into any tributary of any navigable water, or the deposition of solids on the banks where it may be washed into such navigable waters. The Secretary of War is charged with the administration, the maximum penalty being a fine of $1500 or imprisonment for one year, or both, and the minimum penalty a fine of $500, or imprisonment for thirty days, or both, one-half of said fine to be paid to the informant.

S-936. Another bill, S-936, is similar to S-42, except that it refers only to oil in any form and not to other refuse.

S-1388. A third bill, S-1388, is similar to S-936, except that in respect to non-navigable waters it applies only to those connecting navigable waters, and no minimum penalty is set, the maximum being a fine of $2500 or imprisonment for one year, or both.

S-1942. The bill which has passed the Senate, S-1942, makes it unlawful to discharge oil of any kind from ships or from land plants, into coastal navigable waters of the United States (waters in which tide ebbs and flows), but the Secretary of War is authorized to make regulations under which such quantities as shall not be deleterious to health or fish, or dangerous to property, may be permitted. The maximum penalty is a fine of $2500 or imprisonment for one year or both, and the minimum penalty is a fine of $50.

Bills Referred to Committee on Rivers and Harbors. Among the bills referred to the Committee on Rivers and Harbors, and considered at the hearings on January 23, 24, 25, 29 and 30, 1924, there are counterparts of the Senate bills already described. The other bills having special features are described below.

HR-612. This bill applies only to oil pollution by ships, of waters navigable in fact, in which the tide ebbs and flows. The only penalty is a maximum fine of $2500. The administration of the bill is placed in the hands of the Secretary of Commerce, who is empowered to prescribe rules and regulations permitting the discharge of oil under restrictions and to mitigate or remit any penalty. This bill also makes provision for investigations by the Secretary of Commerce, of all sources of pollution affecting navigation. Section 11 of the bill is as follows:

> That the Secretary is authorized and directed to make such investigation as may be necessary to ascertain what polluting substances, the sources thereof, and by what means they are deposited into any of the navigable waters of the United States, including non-navigable waters connecting navigable waters, to such an extent as to endanger or interfere with navigation or commerce upon such waters, or the fisheries therein. The Secretary shall report the results of his investigation to the Congress not later than two years after the passage of this act, together with such recommendations for remedial legislation as he deems advisable.

HR-51. This bill is similar to HR-612, except that the administration is placed in the hands of the Secretary of War, with no provision for investigations, and the maximum penalty is a fine of $2500, or imprisonment for one year, or both. Provision is also made for suspension of the act, by the President, in time of War.

HR-690. This act prohibits the discharge of free acid or acid wastes including mine drainage, into any navigable water or tributary thereof, the maximum penalty being a fine of $2500, or imprisonment for one year, or both, and the minimum a fine of $500 or imprisonment for one year, or both. The Secretary of War is empowered to make rules and regulations. The control is placed in the hands of the Chief of Engineers, who is directed to consult and advise with the owners as to the best practicable and reasonably available means of making such waste harmless.

HR-6256. This act prohibits the discharge of oil from an oil well, terminal, refinery, tank or place of storage, into any navigable river or tributary thereof, with a maximum penalty of a fine of $2500 or imprisonment for one year, and a minimum penalty of $50 fine. The Secretary of the Interior is charged with the administration of this bill and authorized to prescribe regulations.

Prospective Legislation. According to the latest information received, none of these bills has yet passed the House of Representatives, but we are informed on good authority that legislation will

probably be enacted by the House, based on HR-612, and S-1942, already passed by the Senate.

Recent British Legislation. In addition to an act for the protection of waters containing fish, from poisonous matter and trade effluents (Salmon and Fresh Water Fisheries Act, 1923, Part I, Section 8), the British have recently passed very drastic laws bearing on oil pollution ("An Act to make Provision against the Discharge or Escape of Oil into Navigable Waters, enacted in 1923"). This Act applies both to vessels and to places on land. The penalty is a fine not exceeding 100 pounds, which is equivalent to approximately $500. As it appeared impracticable to compel the installation of separating apparatus on any but the largest ships, provision was made for barge service in certain harbors, to collect the oil ballast.

Injunction Decision, City of McKeesport vs. Carnegie Steel Company

On September 16, 1918, the City of McKeesport filed a bill to restrain the Carnegie Steel Company from polluting the Monongahela River by discharging therein waste fluid from its by-product plant at Clanton, Allegheny County, Penna. A hearing on the motion for a preliminary injunction by the plaintiff, the City of McKeesport, was held on September 20, 1918. The testimony showed that the public water supply of the City of McKeesport was adversely affected by the discharge of waste by-product from the Clairton plant into Peters Creek, which empties into the Monongahela River, one of the sources of water supply for the City of McKeesport. The preliminary injunction was granted to the plaintiff. (No. 1647, October Term, 1918, Docket "C".) (Opinion by Justice Brown, filed September 27, 1918.)

Need of Sound Legislation. State legislation is needed in some states, to control adequately industrial wastes pollution within these states. National legislation is needed, to control pollution of interstate and coastal waters. Such legislation, whether state or national, must be considered from the broad viewpoint of public welfare. It should be based on the results of thorough investigation. The importance of securing the coöperation of all interested parties, must not be lost sight of.

Respectfully submitted,

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THE ACTION OF WATER ON SERVICE PIPES[1]

By Wellington Donaldson[2]

Delivery of water from street mains to faucets of the consumers without impairment of the quality of water or without deterioration of the service pipe itself has been a problem since the earliest days of water supply. The great diversity in physical and chemical properties of water has resulted in the use of various pipe materials which experience has found most suitable for a given locality. There is no "one-best" pipe applicable to all conditions, taking into account the elements of quality of water and cost of installation and maintenance.

EXTENT OF USE OF VARIOUS KINDS OF SERVICE PIPE

Comprehensive statistics in regard to various kinds of service pipes are not available to the committee at this time, but attention is called to an interesting recent tabulation prepared by the editor of Public Works based on a questionnaire sent to about 800 cities in all parts of the United States (1), some results of which are summarized in table 1.

The figures cited, although useful in indicating the trend of practice, nevertheless must be taken with reservations because they cover only a small portion of the total works in this country. The number of cities reported on from the different states is quite disproportionate, as the list includes 50 plants in Massachusetts, and only one each in New Hampshire, New Jersey and Utah. The omission of cities of the first rank is notably conspicuous. For instance, the tabulation does not include any of the large cities in New York State and omits such important cities as Philadelphia, Pittsburgh, Cleveland, Cincinnati, Chicago, New Orleans, Birmingham, Memphis, Kansas City, Dallas, San Francisco, Los Angeles, etc.

[1] Contribution to work of Committee No. 10 on Standardization of Services, J. M. Diven, chairman.

[2] With Fuller and McClintock, New York, N. Y.

TABLE 1

Relative use of various service pipe materials for 539 cities of United States

STATE OR PROVINCE	NUMBER OF CITIES LISTED	NUMBER CITIES HAVING SERVICE PIPE OF					
		Galvanized wrought iron or steel	Lead	Cast iron	Lead lined	Cement lined	Wrought iron or steel*
Alabama	8	7	1	1		1	
Arizona	7	5	3				3
Arkansas	9	6	1	1			1
California	29	10	2	2			20
Colorado	11	2	6				5
Connecticut	10	5	4		1		5
Florida	9	2	5	1			4
Georgia	15	5	3		1	1	10
Idaho	9	8	1				
Illinois	37	8	30	3			14
Indiana	44	11	25	2	1		13
Iowa	29	5	25	2	1		13
Kansas	26	8	16	3			18
Kentucky	13	7	7				3
Louisiana	4	1	1				2
Maine	9	4			2	1	6
Maryland	2	1			2		1
Massachusetts	50	12	10	5	8	24	22
Michigan	37	10	16	2			14
Minnesota	27	7	16	2			9
Mississippi	12	3	8			1	9
Missouri	12	2	9	1			7
Montana	9	6	8	1			1
New Hampshire	1					1	
New Jersey	1	1	1				1
New Mexico	2	2					
New York	7	1	4				4
North Carolina	5	2					4
North Dakota	3		3	1			
Ohio	22	6	14				8
Oklahoma	14	3	10	1			6
Oregon	7	5					1
Pennsylvania	14	3	7				10
Rhode Island	3	1	2				
South Carolina	2	2					
South Dakota	3		3				
Tennessee	6	2	5				2
Texas	16	2	10	3			9
Utah	1	1					
Vermont	2		1				1
Washingron	12	9	2				3
Total	539	175	259	31	16	29	229
Per cent of total		32	48	5.7	3	5.4	42

*Coating not stated.

The last column of table 1 evidently arises from a lack of explicitness on the part of cities responding to the questionnaire. The use of "black" or ungalvanized wrought iron and steel pipe for water services is believed to be insignificant, therefore the last column should be included under "galvanized," which would indicate a predominance of galvanized pipe for services, as is believed to be true for the country at large. The use of cast iron for services evidently is limited to sizes of $1\frac{1}{2}$-inch and over, more generally 4-,

TABLE 2

Additional data on service pipe material for 42 cities, mostly in Massachusetts

STATE OR PROVINCE	NUMBER OF CITIES LISTED	NUMBER USING SERVICE PIPE OF						
		Galvanized wrought iron or steel	Lead	Cast iron	Lead lined	Tin lined	Cement lined	Coated* wrought iron
Massachusetts	27	12	15	13	10	4	16	14
Vermont	1	1	1	1				
New Hampshire	2	1	1	1			1	1
Rhode Island	2		2	1				1
Michigan	1	1	1	1				
New Jersey	1		1	1				1
Pennsylvania	2	1	2	1	1			1
Wisconsin	1		1					
Oregon	1	1						
Kentucky	1	1	1					
Connecticut	1	1	1				1	
Ontario	2	1	2	1				
Total	42	20	28	20	11	4	18	18
Per cent of total		47	67	47	26	9.5	43	43

Note: Holyoke, Massachusetts, uses some rubber lined pipe. Includes "enamelled" and "tar coated."

6-, and 8-inch factory connections, and therefore negligible for ordinary domestic use.

Where services are laid in advance of new pavement a decided preference is indicated by the Public Works questionnaire for lead piping.

The New England Water Works Association has published certain statistics (2) comprising 36 New England cities and 9 cities elsewhere in United States and Canada. Data regarding service pipe are summarized in table 2.

LIFE OF SERVICE PIPE

The Public Works questionnaire, already referred to, included data as to life of various service pipe materials, but the results are of uncertain value, as they are obviously "judgment" figures and not based on actual records of service pipe replacement. Covering practically the same cities comprised in table 1, it was shown, in general, that galvanized pipe had a life of from one to thirty-five years, while the life of lead pipe was given as four years to "indefinite." The life of lead-lined pipe was reported as twelve to thirty-five years in the states of Indiana, Maryland and Massachusetts. The life of cement-lined pipe in Maine is reported as fifty years, in Massachusetts from ten to fifty years and in New Hampshire from twenty-five to thirty-five years.

The behavior of various kinds of service pipe, in so far as it relates to action of water on interior surfaces, and not to destruction by electrolysis, outside soil corrosion, or mechanical injury, may be reviewed briefly as follows:

1. Galvanized pipe

Galvanized pipe is probably the most popular service pipe material. It is cheapest in first cost of any pipe having a substantial coating supplied by the manufacturer. It is the easiest pipe installed because of the simple threaded joint and standard fittings. Unfortunately the zinc coating is not a permanently effective protection with many water supplies, while with some supplies corrosion is so rapid as to forbid use of this material. Discolored or rusty water appears in time at the faucet or in the water after heating, tubercles of iron rust form on the interior and may greatly reduce or stop the flow. Deterioration at the joint is apt to proceed rapidly, resulting in leakage.

Extensive study and research as to causes and abatement of iron pipe corrosion as it relates to water supply have been made. Notable among the investigations, concerned chiefly with the action of cold water in domestic service, are those of the Massachusetts Board of Health, 1900–1910 (4), (5), and the New York Board of Water Supply, 1911–1912 (6).

Corrosion factors. The investigations of Whipple (7), (8), of Weston (9) and of Walker (11) have added much to a practical knowledge of the subject, not to mention numerous others making

valuable contributions to some phase of corrosion. The observed and generally accepted facts as to behavior are: (*a*) Corrosion and deterioration of iron or steel service pipe is most prevalent with soft water supplies. (*b*) The principal factor determining the rate of corrosion and amount of iron dissolved is the free carbonic acid in the water, corrosion being most pronounced with high CO_2 content. (*c*) The dissolved oxygen in water accelerates corrosion and is responsible for the appearance of rust or tuberculation. (*d*) Corrosion decreases with increase in hardness of the water supply. (*e*) Galvanized steel pipes corrode more rapidly than galvanized wrought iron. (*f*) Protection of iron or steel galvanized pipe is at expense of the zinc coating which dissolves in the water. (*g*) Workmanship in manufacture and galvanizing is a decided factor in resistance to corrosion. (*h*) Filtration accelerates corrosion by removal of organic matter, and, where coagulants are used, the additional carbonic acid created may be a factor in some cases.

Effect of metals dissolved from iron pipe. The presence of dissolved iron or iron rust even in considerable amounts has no known hygienic significance. Iron in the amounts of 1 to 2 p.p.m. may impart an astringent taste characteristic of this metal, but waters containing much larger amounts are used without detrimental effect. The principal effect is the reddish stain or rust produced in the water, on plumbing fixtures and on clothes during laundry operations.

Zinc dissolved from galvanized pipe usually passes unnoticed and little consideration has been given to its relation to health. Howard (12) has recently summed up the situation as to physical effects and hygienic relations. Opalescence in the water first drawn from faucets in the morning and appearance of a "greasy film" are the visible evidences of appreciable quantities of dissolved zinc, though these evidences are apt to be confused with iron.

Regarding the amount of zinc present in water supplies, Howard states (12) that the New Hampshire tap water commonly contains 5 p.p.m. while 10 to 15 p.p.m. is "rather frequent."

In investigations for the Massachusetts State Board of Health by Clark (3), Clark and Gage (5) amounts of zinc were found ranging from 0 to 3.1 p.p.m. from typical galvanized services less than 100 feet in length in ordinary use. The same services, after letting the water stand over night, gave 2 to 12 times the amount of zinc in ordinary use. Unusually long services gave higher figures than those quoted.

Opinion and evidence as to harmful effects of drinking water contaminated with zinc are conflicting. Evidently the subject needs closer study both on the part of the physician and the water analyst.

Remedies for corrosion of iron pipe. With water supplies containing considerable amounts of carbonic acid, particularly ground waters, aeration has been found effective in reducing corrosion.

Hardening of the supply by addition of, or contact with, limestone has found a limited use.

Treatment of the water with lime has been found effective in numerous cases. Its use was discussed very thoroughly by Whipple (7) and the practical application of lime on a large scale is well-known through the Baltimore experience, as described by Baylis (14), (15). Lime has the disadvantage of increasing the alkalinity and total hardness by 1.14 p.p.m. for each part CO_2 neutralized.

Soda-ash treatment of the water is also a practical remedy against corrosion. It is more expensive than lime treatment, but has the advantage of not increasing the hardness; on the other hand, it reduces the permanent or non-carbonate hardness.

Silicate of soda has been used quite successfully in England as a remedy against corrosion for iron service pipe and red water troubles according to Thresh (16). Treatment with sodium silicate has been found an effective remedy for corrosion of hot water systems in this country according to Texter (20), but so far as known no application to a public water supply has been made.

2. Lead or lead lined pipe

Next to galvanized pipe, lead is most favored for service pipe in this country. In England, according to Mitchell (19), a much larger proportion of services are of lead. It has the longest life and is free from the "red water" troubles common to galvanized iron and steel pipe. The installation cost of the lead service is more than for galvanized.

The greatest drawback to installation of lead service is the fact that lead is distinctly soluble with certain kinds of water and being an active and cumulative poison may constitute a grave menace to the health of those drinking water delivered through lead pipe. This property of lead pipe has been known for more than twenty centuries, and the instances of illness or death from drinking water from lead pipe are quite numerous, as evidenced by citations in the

excellent review of the subject by Weston (10). The instances of lead poisoning from American public water supplies available at the present time to this committee comprise only the New England towns listed in table 3. The list is obviously incomplete and based only on published information. There are a great number of water supplies in this country having characteristics similar to the New England waters where plumbism might be expected, and undoubtedly has occurred. Obscure symptoms, lack of thorough investigations and a fear of arousing public apprehension or of inviting litigation are the principal causes for silence or complacency as to possible plumbism, on the part of cities having a large proportion of lead services.

TABLE 3

Localities in America where lead poisoning has been reported

CITY	YEAR	AUTHORITY	REFERENCE
Fairhaven, Mass.	1898	Clark	(3) (4)
Kingston, Mass.	1898	Clark	(3) (4)
Lowell, Mass.	1898	Clark	(3) (4)
Lowell, Mass.	1899	Barbour	(23)
Milford, Mass.	1898	Clark	(3) (4)
Rhode Island	1916	Gage	(27)
Milford-Hopedale, Mass.	1914	Weston	(10)
Gilbertville, Mass.		Whipple	(7)
Norwood, Mass.		Whipple	(7)
New Bedford, Mass.		Whipple	(7)
New Hampshire		Howard	(13)
Atlantic City, N. J.		Hawley	(30)

Within the past thirty years several thorough investigations as to the solvent and corrosive action of water on lead service pipe have been carried out, resulting in the establishment of certain needed facts, which deserve to be generally recognized.

The occurrence of serious lead poisoning or "plumbism" in certain towns of Central and Northern England having water supplies derived from moorland catchment areas caused the Local Government Board to initiate in 1890 an inquiry as to cause and extent. This investigation carried out by Dr. Houston occupied the better part of five years, the results of which were published in 1902 (21) and 1903 (22).

In 1896 the State Board of Health of Massachusetts prompted by a large number of cases of lead poisoning started an investigation

"to learn the nature and degree of the action of the water of the various public water supplies of the state upon lead, in such towns as use lead or lead-lined service pipes, and to ascertain facts in regard to the occurrence of lead poisoning in those towns." These investigations, covering about four years' work, were published in 1899 (3) and 1901 (4).

These two investigations may be said to have laid the groundwork for an understanding of the problems associated with the corrosion of lead service pipe, but the subsequent contributions by numerous other investigators, both in this country and abroad, must be recognized. In particular, the recent summary of the subject by Weston (10) should be mentioned.

Action of water on lead. Distilled water, completely free from dissolved gases, has no action on lead. In distilled water containing only dissolved oxygen, lead is dissolved with formation of the colloidal hydrate, giving an alkaline reaction to the liquid, which remains clear. The oxygen is used up unless in excess, in which case a deposit of definite crystalline character forms at the sautration point, stated by Thresh (17) to be about 20 mgm. per 100 cc. If carbon dioxide is present in addition to oxygen, a white turbidity appears due to formation of the oxycarbonate, and precipitation occurs on standing. Excess of carbon dioxide dissolves the lead as a bicarbonate, the liquid being clear. In presence of acids, lead undergoes true solution, in which form it is not removable by fine materials such as paper, Gooch, and Berkfeld filters.

These fundamental facts reported from carefully controlled laboratory experiments serve to explain the behavior of lead service pipe in actual water works practice. The two elements most concerned in lead corrosion, namely oxygen and carbonic acid, are present in most public water supplies, as distributed. In addition some surface water contains organic acid due to decomposition of vegetable matter.

In considering lead corrosion, it is important to distinguish clearly between what happens in (*a*) neutral or alkaline water in the presence of oxygen and (*b*) that occurring in acid water or in slightly alkaline water containing high carbonic acid, with or without oxygen. In the first condition, the metal becomes scaled and the water is made turbid. "Erosion" is the term generally used to describe this action, though it has been referred to, not inaptly, as "lead rusting;" while "solvency," or "plumbo-solvency," describes the second condition, where lead enters into true solution.

Conditions for lead erosion. Ordinary distilled water, rain water and melted snow erode rapidly, but do not dissolve lead appreciably. Natural water of low alkalinity and low CO_2 act similarly. Erosion decreases with an increase in alkalinity, the controlling amounts, according to Weston (10), for water containing less than 30 p.p.m. CO_2 being:

Alkalinity less than 15 p.p.m.—erosion, precipitate forms, metal appears bright, but mottled
Alkalinity 15 to 25 p.p.m.—rarely erode, crust of basic carbonate forms
Alkalinity over 25 p.p.m.—no erosion, protective coat forms

Condition for lead solvency. The controlling factor in lead-solvency is "acidity," from free carbonic acid, humic or peaty acids, or mineral acid. Those natural waters dissolving lead to an appreciable extent are (*a*) soft ground waters, high in carbonic acid, or (*b*) soft colored water derived from swampy catchment areas. The Massachusetts cases of lead-poisoning referred to above belong to the former class, while the English cases of plumbism were related to the latter class. Although no instances of plumbism from water containing mineral acid are known to this Committee, the possibility should be recognized. Many of our important public water supplies are taken from streams, actually acid or on the border line due to acid mine drainage or acid industrial wastes. The effect on lead services of chlorination of the supply has been stated in at least one instance, though the matter needs confirmation.

When is a water supply safe from lead. In connection with the early Massachusetts investigation, Clark and Forbes state (4) "a potable water in Massachusetts to have any dangerous lead dissolving action must contain considerable free carbonic acid." In the case of Lowell, Fairhaven, Kingston and Milford where plumbism occurred, the CO_2 ranged from 16 to 29 p.p.m. and the hardness from 10 to 28 p.p.m. At Lowell the Cook well water, condemned on account of its lead solvency, had an alkalinity of about 33 p.p.m., hardness of 55 and CO_2 content of 45 p.p.m., according to a later investigation by Barbour (23). Thresh states (19) that 40 p.p.m. alkalinity is required entirely to prevent action on lead. It is obvious that the solvency depends not on CO_2 content alone but on "true" acidity or "hydrogen-ion concentration," a term made very familiar to water works men within the last two or three years.

In the case of the peaty Moorland waters of England, Houston (21) (22) established a correlation between plumbo-solvency and the acidity to lacmoid. Lacmoid gives color changes from pH 4.4 red to 6.2 blue, according to W. Mansfield Clark (25). The English test is made very simply by adding a drop of lacmoid indicator to 10 cc. of water in a test tube, in the cold. A red color indicates acidity, and water giving this reaction was found by Houston to be plumbo-solvent. The action on lead was proportionate to the acidity. The amount of acidity is determined by titrating 100 cc. of water with sodium carbonate and phenolphthalein, in the cold. This conforms to our A. P. H. A. test for "total acidity" (26), and in the absence of organic or mineral acids represents "free carbon dioxide."

Thresh in a study of 42 Moorland waters (16) found pH ranging from 4.0 to 7.5 with an average of pH 6.3. These waters contained CO_2 (volatile acid) ranging from 1.0 to 5.5 p.p.m., non-volatile acidity from 0 to 15 p.p.m., alkalinity from 0 to 7.5 and hardness from 7.3 to 90.0 p.p.m. Although all the waters dissolved lead in laboratory tests, correlation of the figures stated with actual behavior in services was not shown.

Another test for action of water on lead is the "foil test" devised by Houston and modified by Liverseege and Knapp (see Weston, 10). A bright polished strip of sheet lead $\frac{1}{2}$ by 1 inch is submerged in a glass cylinder with water tested, from one to fourteen days. Erosion is apparent from the appearance and solvency is determined on a decanted portion, by suitable analytical methods.

Still another test of water for its action on lead is the "shot test," also due to Houston (21) and modified by Thresh (19). It consists in passing the water at a specified slow rate through a glass tube filled with clean pure lead shot, and determining the lead in the effluent.

On samples brought into the laboratory, corrosion tests sometimes fail to indicate the true condition as to lead corrosion in the distribution system. The London tap water cited by Thresh (19) and the Boston tap water cited by Weston (10) are examples of water supplies not giving rise to plumbism, yet showing considerable amounts of lead dissolved in laboratory tests. The differences are due to the protective coating found in the service pipe. Such protection may be due to films of organic matter, basic lead carbonate, or of lime or silica introduced artificially. For these reasons,

lead determinations on samples collected from service pipes in actual use are necessary for a complete study of the problem.

In sampling service pipe it should be borne in mind that the water standing in lead pipes dissolves more lead than when the faucets are used frequently. The Massachusetts investigations, already quoted, showed an average lead content of 0.37 p.p.m. in 16 ground-water supplies as sampled from the faucet in ordinary use, while the same faucet after standing over-night yielded 0.70 p.p.m. Similarly 6 surface supplies gave 0.02 and 0.44 p.p.m. respectively.

Physiological effects of lead in drinking water. The list of physiological symptoms attributed to lead-poisoning is formidable, these varying from mild unwellness, general debility, constipation, rheumatism, anemia, colic, contracted granular kidney, transient blindness, inflammation or atrophy of optic nerve, degeneration of blood vessels of the eye, to death. The susceptibility of individuals varies materially.

Permissible amounts of lead in drinking water. On this matter, opinion varies widely. Some authorities regard any amount of lead detectable by usual method of analysis as potentially dangerous, when the water is habitually drunk. An amount as high as 1.5 p.p.m. has been used without illness resulting, yet many cases of lead-poisoning have resulted from smaller amounts. Gage records (27) poisoning in Rhode Island from 0.2 p.p.m. Howard (13) in discussing the experience of the New Hampshire Board of Health, engaged for some twenty years in studying the relation of lead to water supplies, states that the formerly prevalent idea that 0.5 p.p.m. was a safe limit has been modified in the light of known cases of poisoning by half that amount. Weston (10) regards 0.1 p.p.m. as a practical safe limit though not necessarily a limiting maximum.

Protective measures. Treatment of waters to prevent corrosive action on lead pipe is neither difficult nor expensive. Such treatment has to do with elimination of acidity, building up a protecting alkalinity or formation of a protective coating without disturbing the chemical constituents of the water.

Aeration, in the case of ground waters containing high carbonic acid, is frequently a simple and effective means of reducing this constituent. With soft waters, however, aeration may be actually detrimental by reason of the dissolved oxygen added which increases the tendency towards erosion. Removal of carbonic acid by aeration is never complete. The most efficient aeration with

spray nozzles was found in the Memphis experiments by Donaldson (28) to leave a residual of about 3 p.p.m. while other types of aerators gave somewhat higher residual, on a water containing about 28 p.p.m. CO_2.

Application of lime to the water will completely neutralize all acidity. With ground waters high in carbonic acid it is better to first aerate in order to avoid increasing hardness of the water to an appreciable extent. American practice shows a preference for hydrated lime, fed with dry feed machines, rather than ordinary lump or quick lime.

Application of soda-ash serves the same purpose as lime in neutralizing acidity. It is more expensive, but does not harden water. Dry feed machines or solution tanks are equally serviceable for soda-ash.

Filtration through beds of limestone used to considerable extent in England has not found favor here, direct chemical treatment being preferred.

The application of sodium silicate has been tried in England with good results, but so far as known has not been used here in the treatment of public water supplies. It is stated to have a greater protective value than lime. There are numerous grades or varieties of silicate. That recommended for water purification has the composition Na_2O, 9 per cent, SiO_2, 29 per cent, water, 62 per cent (ratio 1:2.40). It is a slightly viscous fluid, best applied with a calibrated orifice valve arrangement.

3. Other service pipe materials

As shown by table 1, tin-lined pipe is used to some extent for services. It was in fact recommended in the 1898 Massachusetts Report. Weston has shown (9) that tin-lined lead pipe is not a protection against lead corrosion, lead being dissolved in spite of the tin lining which remains intact.

Table 1 indicates that cement-lined pipe has considerable vogue in New England, but not elsewhere. This pipe has no appreciable effect on water passing through it and its use eliminates iron rust troubles except as these are due to the iron in the supply or to house plumbing troubles. The danger of lead-poisoning is of course eliminated by cement-lined pipe. The technique of protecting joints and of producing a satisfactory cement lining in the average

water works shop has deterred more general adoption of this kind of service pipe, though such difficulties are held lightly by those accustomed to the use of such pipe.

The behavior of brass service pipe hardly deserves mention as its use is very limited, on account of the expense. In a number of cities where the water supply is corrosive, some consumers have all-brass house plumbing, but the use of brass pipe for services in the street is exceptional. Brass pipe is usually affected little by water, though measureable amounts of both zinc and copper have been found in water from brass pipe (4).

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PROGRESS REPORT OF COMMITTEE NO. 12 ON TESTING OF WATER WORKS MATERIALS AND SUPPLIES[1]

The committee has had its present organization only since the last annual meeting. On June 19, following general instructions from the President, a tentative outline of work of the committee was written by its chairman and sent to the President for approval. This outline, containing assignment of sub-committees, was published in the Journal. The committee members are spread from Boston to Kansas City and have not yet met. Some progress has been made, however, by individual work and correspondence and the results are presented herewith for the information of the Association and as a basis for discussion. The committee itself will meet at the coming annual meeting for discussion of this tentative report and to outline work for another year.

It has been assumed that Committee 12 is responsible for "testing" and hence for "specifications" under which are to be tested all materials not specifically covered by other committees, to wit; the following:

Committee on Standard Specifications for Water-meters
Committee on Standard Brass Fittings
Committee 9 on Standard Specifications for C. I. Pipe and Specials
Committee 10 on Standardization of Services
Committee 17 on Steel Pipe Lines

It may be fitting also for the committee to assemble accepted general rules for testing and inspection that will be applicable to all materials.

The words "materials and supplies" are not interpreted to include fabricated articles of a considerable degree of complication, such as pumps, stand-pipes, wood stave pipes, flexible-jointed pipes, hydrants, etc. These, though not covered by special committees, are manifestly too important to be lumped into the work of this committee and will only be considered from the viewpoint of covering

[1] This report has been prepared under the direction of Council, by Committee No. 12, Thomas H. Wiggin, Chairman.

the basic materials, such as rolled, cast and forged steel, cast iron, bronze, rubber, etc., which enter into their construction.

Obviously with all the standardization work that has been done by the American Society for Testing Materials, the American Engineering Standards Committee, the Bureau of Standards and other bodies jointly and severally, it is unnecessary for this committee to inaugurate new work on many important materials such as steel, cement, etc. Further on in the report the endeavor has been made to list such generally accepted standard specifications as exist and to give clear references which will enable members who are not familiar with these existing specifications to avail themselves of them.

By way of introduction to these references a brief explanation may not be amiss as to the rather complicated agencies that now exist in the United States for the compilation of standard specifications. Previous to the war the American Society for Testing Materials was the chief agency for concerted action of the engineering profession in making standard specifications. In general each separate society worked up and adopted its own specifications for materials and supplies with which it was primarily interested.

In 1917 concerted action was taken by the American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Society for Testing Materials in establishing the American Engineering Standards Committee as a clearing house for specifications. There are now 205 national organizations participating in the A. E. S. C. work. The committee has offices in the Engineering Societies Building, 29 West 39th Street, New York City, with a paid secretarial personnel.

The American Engineering Standards Committee is a coördinating body. It neither proposes nor formulates specifications, but, when the demand for a standard specification is demonstrated, it aims to secure the widest practicable participation in the formulation of the specification and in its subsequent adoption. The specifications are formulated by so-called "Sectional Committees" having the special support of so-called "sponsor" organizations, which sponsors publish the specifications. Specifications which have been approved by the A. E. S. C. as American Standards or as Tentative American Standards are on sale separately by the A. E. S. C. as well as by the sponsors.

Some of the materials and supplies in which waterworks men are interested have already been acted upon or are in process of consideration by the A. E. S. C. Specifications for Portland cement and for pipe threads are two examples of specifications that have been so acted upon. Cast iron pipe and lime are examples of those under consideration. Action by the A. E. S. C. tends to delay a specification but to make it more broadly applicable. The various individual societies like our own must continue to work out their own salvation and must also keep in touch with the A. E. S. C. to make the products of their own work more generally useful and to be sure that their own special needs are properly represented in the Sectional Committees of the A. E. S. C.

Nearly all the specifications referred to below are American Society for Testing Materials Standards or tentative standards.[2] In some cases they are also A. E. S. C. Standards and are marked A. S. (American Standard) or T. A. S. (Tentative American Standard).

A. S. T. M. standards and tentative standards are all copyrighted in the name of the A. S. T. M. Permission to reprint any of these standards and tentative standards can be obtained only from the Executive Committee on application to the Secretary-Treasurer of the A. S. T. M., but it is usually sufficient to specify by name and serial designation of the A. S. T. M. Standard as in the following example: Plates for stand pipe shall fulfill the requirements for "Flange Steel" as given in the Standard Specifications for Boiler and Fire Box Steel for Locomotives, Serial designation A 30–21, of the

[2] A.S.T.M. Standard Specifications are published every third year, the last being 1921. Standards adopted in intervening years are published annually in a separate pamphlet. Tentative specifications are published annually in a volume containing all tentative specifications effective at the time. Tentative specifications are subject to revision at any time until adopted as standard; the latest edition should therefore be obtained. Pamphlets of separate standard or tentative specifications are sold at 25 cents per copy in lots of 1 to 50, less in quantities. Address American Soc. for Testing Materials, 1315 Spruce Street, Philadelphia, Pa., giving both serial designation and title of the specification. Thus, C 9-21 is Standard Specification for Portland Cement, the 21 designating year in which adopted or in which last revised. The number of a tentative specification is always followed by the letter T, thus A27-23T is tentative specification for steel castings.

For complete list of all Standard and Tentative Standard Specifications and for further particulars, see Year Book of A.S.T.M. ($1.00 to non-members).

American Society for Testing Materials. These specifications generally provide for the inspection of materials at the place of manufacture unless otherwise specified.

SPECIFICATIONS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS

Steel

Standard and Tentative Standard Specifications for:

A 9-21 Structural Steel for Buildings. Covers open hearth rivet steel and both Bessemer and open hearth structural steel.

A 15-14 Billet-Steel Concrete Reinforcement Bars. Covers (*a*) plain, deformed and cold-twisted billet-steel bars; (*b*) plain and deformed bars of three grades, namely; structural-steel, intermediate and hard; and (*c*) cold-twisted bars.

A 16-14 Rail-Steel Concrete Reinforcement Bars. Covers plain, deformed and hot-twisted rail-steel bars.

A 27-21 Steel Castings. (See A 27-23 T.)

A 27–23 T Steel Castings (Tentative; to replace, when adopted, A 27-21). These alternative specifications cover Class A castings for which physical requirements are not, and Class B castings for which physical requirements are specified, the latter of three grades, hard, medium and soft. A 27-23 T differs from A 27-21 in that it accepts for Class A castings a higher carbon content subject to heat treatment, and for Class B castings requires greater elongation and reduction of area, but requires no bend test unless specified in the order.

A 36-14 Recommended Practice for Annealing of Carbon-Steel Castings. (See A 36-22 T.)

A 36-22 T Tentative Recommended Practice for Heat Treatment of Carbon-Steel Castings. (To replace, when adopted, A 36-14.)

A 36-14 Corresponds to A 27-21 though not specified therein; A 36-22 T is specified in A 27-23 T.

A 30-21 Boiler and Firebox Steel for Locomotives. "Flange steel" of A 30-21 used for boiler shells (not fireboxes), riveted pipes, standpipes and important tanks.

A 31-21 Boiler Rivet Steel. For boiler, pipe, standpipe and tank rivets.

Wrought Iron

Standard Specifications for:

A 72–21 Welded Wrought-Iron Pipe. (T.A.S.) Covers "standard" and "extra-strong" welded wrought iron pipe, $\frac{1}{8}$ inch to more than 12 inch diameter, but not "double extra-strong" pipe; includes pipe of "coiling or bending quality."

Standard Definitions of:

A 81-21 Terms Relating to Wrought-Iron Specifications.

Cast Iron and Finished Iron Castings

Standard Specifications for:

A 44-04 Cast-Iron Pipe and Special Castings. Listed as a matter of information. Differs from American Water Works Association Standard chiefly in a few minor differences in dimensions, and in accepting a load on test bar for pipe 12 inches or less in diameter of 1900 pounds instead of 2000 pounds, and in requiring a deflection under 2000 pounds load of 0.32 inch instead of 0.30 inch in bars for pipe larger than 12 inches; also does not provide for alternative tensile test.

A 74-18 Cast-Iron Soil Pipe and Fittings.

A 47-19 Malleable Castings. Covers malleable castings for railroad, motor vehicle, agricultural implement and general machinery purposes, produced by either air-furnace, open-hearth, or electric-furnace process, and specifies same properties and tests for all.

A 48-18 Gray-Iron Castings. Covers "light," "medium" and "heavy" castings with different test requirements for each class.

Standard Methods of:

A 64-16 Sampling and Chemical Analysis of Pig and Cast Iron.

Metallic Protective Coatings for Iron and Steel

Tentative Methods of:

A 90-23 T Determining Weight of Coating on Zinc-Coated Articles. Describes one shop weighing test, three laboratory and three field tests, one of the laboratory methods being a tentative standard.

Non-Ferrous Metals

Standard and Tentative Standard Specifications for:

B 7-14 Manganese-Bronze Ingots for Sand Castings. This specification is for ingots, such as might be used in a water department foundry, not for manganese-bronze castings; the properties of the castings being largely dependent upon details of foundry practice, may be quite different.

B 10-18 The Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent. Covers the alloy commercially known as government bronze, admiralty gun-metal, gun-metal, or 88-10-2 mixture, when used in castings.

B 15-18 Brass Forging Rod. Covers rods of any specified cross-section capable of being readily forged hot and easily machined; chemical requirements but no tensile tests.

B 21-19 Naval Brass Rods for Structural Purposes. Covers rods of any uniform cross section, such as round, hexagonal, square, etc., requirements varying with diameter. Suitable for structural purposes as rods, bolts, etc., and is capable of being forged hot but is not free cutting.

B 31-21 Bronze Bearing Metal in Ingot Form. Covers 6 grades of copper-tin-lead alloys, made wholly or partly from scrap material.

B 32-21 Solder Metal. Covers two classes and a total of 11 grades of lead-tin alloys used for "soft solder."

B 42-23 Copper Pipe, Standard Sizes. Covers seamless copper tubes and pipe suitable for use in plumbing, boiler feed lines, etc.; bending temper to be specified if required.

B 43-23 Brass Pipe, Standard Sizes. Covers seamless brass pipe suitable for use in plumbing, boiler feed lines, etc.; bending stock to be specified if required.

B 30-22 Brass Ingot Metal, Graded and Ungraded, for Sand Castings. Covers "red" and "yellow" brass ingot, made wholly or partly from scrap; seven grades, also ungraded.

B 44-23 T Seamless Admiralty Condenser Tubes and Ferrule Stock (Tentative). Covers seamless tubes and ferrule stock made from admiralty alloy, 70 per cent copper, 1 per cent tin, and 29 per cent zinc.

Standard Methods of Chemical Analysis of:

B 18-21 Alloys of Lead, Tin, Antimony and Copper. (T.A S.)

B 27-19 Manganese Bronze. (T.A.S.)

B 28-19 Gun Metal. (T.A S.)

B 45-23 Brass Ingots and Sand Castings.

B 46-23 Bronze Bearing Metal.

Cement, Lime and Clay Products

Standard and Tentative Specifications for:

C 9-21 Portland Cement (A.S.)

C 9-16 T Compressive Strength of Portland Cement Mortars. (To be added when approved, to C 9-21.)

C 10-09 Natural Cement.

C 33-23 T Concrete Aggregates. Covers fine and coarse aggregates including sand, stone screenings, crushed stone, gravel and slag. Acceptance based on description and sieve tests plus concrete strength tests: or alternatively for sand, on mortar strength tests.

Standard and Tentative Methods of:

C 29-21 Test for Unit Weight of Aggregate for Concrete (T.A.S.) To determine weight of a given volume of dry aggregate, fine, coarse or mixed, with air-filled voids, relative to the same volume of water.

C 30-22 Test for Voids in Fine Aggregate for Concrete. (T.A.S.) Requires determination of "apparent specific gravity" by methods of D 55.

C 31-21 Making and Storing Specimens of Concrete in the Field. Covers molding and storing of test specimens sampled from concrete being used in construction.

C 39-21 T Making Compression Tests of Concrete.

C 40-22 Test for Organic Impurities in Sands for Concrete. (T.A.S.) Covers the sodium hydroxide test, which test is intended as an indication whether the presence of organic compounds requires further tests of the sand before its use in concrete.

C 41-22 Test for Sieve-Analysis of Aggregates for Concrete.

C 42-21 T Securing Specimens of Hardened Concrete from the Structure (Tentative).

C 44-22 T Tentative Rules for Inspection of Concrete and Reinforced Concrete Work. Covers qualifications of the inspector, and his duties in detail.

C 7-15 Paving Brick. Covers rattler test and visual inspection only.

C 21-20 Building Brick. Covers absorption, compression and transverse tests.

C 32-23 Clay Sewer Brick. Covers four classes according to resistance to abrasion required; provides for optional chemical tests and requirements; specific size, visual inspection, absorption, compression and transverse tests.

C 4-21 Drain Tile. (T.A.S.) Covers three classes, Farm Drain Tile, Standard Drain Tile and Extra-Quality Drain Tile, 4 to 42 inches.

C 13-20 Clay Sewer Pipe. Covers clay products intended to be used for the conveyance of sewage, industrial wastes, and storm water. Sizes 4 to 42 inches.

C 14-20 Cement-Concrete Sewer Pipe. Covers cement-concrete products intended for the conveyance of sewage, industrial wastes and storm water. Sizes 4 to 42 inches.

C 15-17 T Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (Tentative). Gives required safe crushing strengths per linear foot of pipe, for different kinds and depths of ditch filling material over pipe, and different widths of ditch, when pipe is laid in accordance with C 12-19.

Standard Definitions of:

C 8-15 Terms Relating to Sewer Pipe.

Recommended Practice for:

C 12-19 Laying Sewer Pipe.

Coal, Coke and Lubricants

Standard Methods of:

D 21-16 Sampling Coal. (T.A.S.)

D 22-21 Laboratory Sampling and Analysis of Coal.

D 22-23 Test for Fusibility of Coal Ash (To be combined with D 22-21 when the 1924 Book of A.S.T.M. Standards is issued).

D 37-21 Laboratory Sampling and Analysis of Coke. (T.A.S.)

D 47-21 Testing Lubricants (Specific Gravity, Free Acid, Carbon Residue, Viscosity).

Definitions of:

D 121-21 T Terms Relating to Coke (Tentative).

D 142-22 T Terms Relating to Coal (Tentative).

Timber

Standard and Tentative Specifications for:

D 10-15 Yellow-Pine Bridge and Trestle Timbers.

D 23-20 T Structural Douglas Fir (Tentative). Covers "dense Douglas fir" and two structural grades.

Standard Specifications of:

D 9-15 Terms Relating to Structural Timber.

Rubber Products

Standard and Tentative Specifications for:

D 14-23 Cotton Rubber-Lined Fire Hose for Private Fire Department use. Covers hose from 1½ inch single and double jacket to 3½ inch double and triple jacket.

D 26-23 Cotton Rubber-Lined Fire Hose for Public Fire Department Use. Covers 2½, 3 and 3½ inches double-jacketted hose.

D 53-23 T Rubber Belting for Power Transmission (Tentative). Covers friction covered and rubber covered belting.

D 151-23 Rubber Pump Valves. Covers valves for pumps equipped with grid-type seats and which are used for pumping fluids having very slight, if any, effect on rubber; five grades for various temperatures and pressures.

D 177-23 T Wrapped Cold Water Hose (Tentative). Covers cold water hose for other than public fire department use; sizes, ½-inch to 4 inches.

Standard Methods of:

D 15-15 Testing Cotton Rubber-Lined Hose.

Road Materials—Aggregates

Standard Method of Test for:

D 30-18 Apparent Specific Gravity of Coarse Aggregates.

D 55-19 Apparent Specific Gravity of Sand, Stone and Slag Screenings and other Fine Non-Bituminous Highway Materials. Primarily for highway materials but used in determining voids in fine aggregates for concrete, C 30-22.

Miscellaneous Subjects

E 1-18 Standard Method of Mechanical Testing of Metallic Materials. Covers methods for tension tests, compression tests, transverse tests and Brinell hardness tests; also calibration of testing machines.

E 4-23 T Tentative Methods of Verification of Testing Machines. (To supersede, when adopted, the corresponding parts of E 1-18).

E 6-23 T Tentative Definitions of Terms Relating to Methods of Testing.

SPECIFICATIONS OF THE AMERICAN ENGINEERING STANDARDS COMMITTEE

A number of the A.S.T.M. Standards have been adopted by the American Engineering Standards Committee as American Standards or Tentative American Standards, of which the following have been previously listed (A.S.T.M. designations): A 72-21, B 18-21, B 27-19, B 28-19, C 9-21, C 29-21, C 30-22, C 40-22, C 4-21, D 21-16, D 37-21.

The following additional A.E.S.C. specification is presented (A.E.S.C. designation):

B 2-1919 Pipe Thread (American Standard). Sponsored by American Gas Association and American Society of Mechanical Engineers.

MISCELLANEOUS SPECIFICATIONS SUGGESTED FOR DISCUSSION

The following specifications have been reported by various subcommittees of Committee 12. Some of them have been in satisfactory use for years and are doubtless known to members of the Association engaged in work requiring such materials. Some are modifications of standard specifications listed above. Alterations from common wording are indicated in a few cases. All are offered for information and for discussion.

Lead

Lead shall be No. 1 quality—pure, soft lead practically free from all impurities. It shall show upon analysis not less than 99.5 per cent by weight of pure metallic lead.

Jute

Jute shall be clean, sound, long fibre jute yarn, free from tar.

Portland Cement

The A. S. T. M. Standard specification for portland cement, C9—21, which is also the American Standard of the A.E.S. Co., is presented with full realization that our knowledge of portland cement is imperfect and that a cement meeting the requirements of this specification may not produce sound concrete and durable structures, under certain occasional conditions, particularly with weather exposure. Pending a more comprehensive study than has yet been made, C 9—21 is the only generally recognized specification available. The Board of Water Supply of the City of New York uses C 9—21 except for the following requirements:

a. Sulphuric anhydride (SO_3) and magnesium oxide (MgO) shall not exceed 1.75 per cent and 4.00 per cent respectively, these being the values in force before specification C 9 was relaxed in 1917; and

b. In recent specifications only, the molecular ratio of the calcium oxide divided by the sum of the molecular ratios of the silicia, alumina and ferric oxide shall, in general, be greater than 2.40.

The sulphuric anhydride and magnesium oxide are held down mainly because there appears to be no sufficient reason for relaxing these requirements. The molecular ratio requirement is designed to insure sufficient lime to produce the several cementing ingredients

in what seem to be desirable proportions;[3] and while this requirement has not been in force long enough conclusively to prove its worth, the indications are that it is a useful provision, at least with current American cements. No case of disintegration of *underground* concrete placed either before or since the adoption of this requirement is known, except where exposed to sulphate ground waters.

Bronze

The specification B 7—14, noted above, is for manganese-bronze ingots, not for castings. The following specifications are used by the Board of Water Supply of the City of New York for manganese or Tobin bronze castings and forgings.

	MINIMUM REQUIREMENTS		
	Castings	Forgings (a)	Forgings (b)
Ultimate strength, pound per square inch...	65,000	70,000	80,000
Yield point, pound per square inch.....	32,000	35,000	40,000
Elongation, per cent.....	25.0	28.0	22.5

After being forged into a bar, rolled, forged or extruded bronze shall stand, first, hammering hot to a fine point; second, bending cold through an angle of 120 degrees to a radius equal to the thickness of the bar without showing signsof fracture.

All forged, extruded or hot-rolled bronze shall be subject to test with a scleroscope, and if a hardness is found materially exceeding that typical of hot-worked metal, the bronze shall be rejected or annealed promptly, as directed.

All bronze articles shall be made of new metal, shall be free from objectionable imperfections and shall conform accurately to required dimensions. The use of chaplets will not be permitted in centering or anchoring cores in cored pressure castings. When any material is being machined or inspected, if the metal shows signs of imperfect mixing it shall be rejected. All bronze castings, stems, rods, bolts, tubes and plates shall be free from season cracks, surface cracks or other defects; any casting, stem, rod, bolt, tube, or plate which develops any such defects within a year after delivery shall be promptly replaced at the Contractor's expense.

Bronze stems shall be forged from cast billets machined to remove imperfections. The reduction, by forging, of the cast billets shall be sufficient to carry the working of the metal to the denter of the completed stem or rod.

[3] "Judging the Quality of Portland Cement," by R. J. Colony, Trans. Am. Inst. Mining Eng., 1921.

If required, test-pieces shall be cut from the center of the stems to show the condition of the metal at that point. Bronze rods shall be forged, hot rolled or extruded from cast and machined billets. All bronze plates shall be hot rolled, except plates less than ¼ inch thick, which may be cold rolled and annealed. All bronze tubing shall be seamless-drawn, semi-annealed, made of approved commercial bronze. All bronze bolts shall be machined from rolled or extruded rods the full size of the heads. No cold rolling, cold passing or cold drawing will be allowed except for plates less than ¼ inch thick and for tubing. Cold straightening shall be done by approved bending.

Test-pieces for stems, rods, bolts or plates shall be provided as directed, the number required depending upon the importance of the work. Test-pieces for forgings shall be cut from the full-size section of the finished forgings. In large forgings, the test-piece shall be taken from a point located from the outer shell a distance equal to one-sixth of the diameter of the forged rod.

Patching or plugging of bronze castings will not be allowed, except for minor defects, and then only when and in such manner as may be approved. Welding or burning will not be allowed.

The prohibition of welding or burning for the patching of imperfect bronze castings is now absolute; no castings are known to have cracked that had not been burned, and there are few if any burned castings but have cracked, some cracks not developing for years. Bronze forgings are used chiefly for valve stems. All of the forgings which have been long in service were bought under substantially specification (*a*); the higher strength and lower elongation of specification (*b*) has been used only since 1922 with a view to getting a stiffer stem and one less likely to grind in the nut. The specifications for rolled or extruded manganese bronze are omitted as this material is rarely used. Bronze bolts, being subject to fatigue failure if overstressed in assembling, are not used in vital places. Yield point is specified, since, in the copper alloys at least, this rather than ultimate strength limits working stresses. Chemical properties are not specified.

Galvanizing

The first steps toward the formulation of standard specifications for the zinc coating of materials of iron and steel were taken at a conference held in New York on January 29 under the auspices of the American Engineering Standards Committee. At this meeting your committee was represented, and the fact that a protective coating which gives good service under atmospheric exposure may be wholly inadequate with under-water exposure was brought out.

The tentative program contemplates specifications for the zinc coating, for different classes of exposure, of all classes of iron and steel materials commonly galvanized. It is the purpose of your committee to keep in touch with this work.

CHEMICALS USED IN WATER PURIFICATION

Quick Lime

Section 1. All lime furnished under this contract shall be the best quality of fresh burned fat lime, crushed and ground so that no lumps shall be greater than two inches in any dimension.

Sec. 2. The lime shall be delivered in tight box cars, loaded in bulk. Especial care shall be exercised to close all openings by which the lime might sift out, and to prevent the circulation of air and the admission of moisture.

Sec. 3. The lime shall be delivered at a uniform rate not to exceed....tons per week, as shall be directed.

Sec. 4. The percentage of water soluble calcium oxide in each car load lot of lime delivered will be determined from the analysis of a composite sample collected on its arrival at the water purification works. For any car load lot containing 88 per cent of water-soluble calcium oxide the City will pay to the Contractor the price per ton stated in the proposal. It is hereby agreed that the City shall pay a bonus of one and one-half per cent (1.5 %) of the contract price per ton for each one per cent (1%) by which the water-soluble calcium oxide in any carload lot delivered shall exceed eighty-eight per cent (88%) and shall deduct a penalty of one and one-half per cent (1.5%) of the contract price per ton for each one per cent (1%) by which the water-soluble calcium oxide in any carload lot shall be less than 88 per cent.

Sec. 5. If, in any carload lot, the material as delivered shall contain less than eighty-two per cent (82%) of water-soluble calcium oxide it will be rejected and shall be removed by the Contractor at his expense, and the cost of unloading the material from and reloading into the car shall be deducting from the amount payable to the Contractor under the terms of this contract.

Sec. 6. The carload lot as a unit will be used as the basis of accounting and determining the amount payable to the Contractor under this contract.

Note: A Sectional Committee of the A.E.S.C. is working on specifications for lime for all purposes. The A. W. W. Assn. is represented on this Committee.

Soda Ash

Section 1. The soda ash shall be that known as 58 per cent light soda ash, and shall contain not less than 98 per cent sodium carbonate. The material shall be in a dry powdered form, shall contain no large lumps or large crystals, shall be free from chips and other foreign matter.

Sec. 2. The material shall be packed in bags 100, 200 or 300 pounds per bag, bags to become property of the Purchaser. Shipments of soda ash shall start .....19.. and shall continue at a uniform rate of not less than ....tons per week, or at such increased rate not to exceed....tons per week, as shall be directed.

Sulphate of Alumina

Section 1. The material shall be that known as basic sulphate of alumina, containing no free acid. It shall be crushed into small lumps ranging in size from — to— inch, and shall be free from chips and other foreign matter. It shall contain not less than 17 per cent of available water soluble alumina, Al_2O_3, and of this alumina content there shall be at least 0.5 per cent[4] of its weight in excess of amount theoretically required to combine with the sulphuric acid present. The material shall contain not more than 0.5 per cent of matter insoluble in cold distilled water.

Sec. 2. Sulphate of alumina shall be shipped, unsacked, in tight box cars; the cars shall be thoroughly cleaned before leading, the door openings shall be boarded up to a suitable height, and all openings by which the material might waste shall be carefully closed.

Sec. 3. Each carload lot of material will be analyzed, on delivery, and the acceptance of the lot will be determined by the amount of alumina and of insoluble matter shown by this analysis to be present.

Sec. 4. If the material in any carload lot as delivered fails to meet the specifications of Section 1, it will be rejected and shall be removed by the Contractor at his own expense, and the cost of unloading and reloading the material shall be deducted from the amounts payable to the Contractor under this contract.

Committee No. 4 of the Association is investigating this subject and will probably make suggestions as to the best composition of coagulants.

Bauxite

Section 1. The bauxite shall be crushed and dried to contain not over four per cent (4%) moisture. Unless otherwise permitted the analysis shall satisfy the following specifications:

Al_2O_3 not less than 54 per cent

FE_2O_3 not more than 5 per cent

Sec. 2. Bauxite shall be shipped unsacked in tight box cars; the cars shall be thoroughly cleaned before loading, the door openings shall be boarded up to a suitable height and all openings by which the material might waste shall be carefully closed.

Sec. 3. Deliveries shall begin..... and continue at the rate of .... cars per month.

Sulphuric Acid

Section 1. The Sulphuric Acid shall be approximately 60 degrees Baume at 60 degrees Fahrenheit. It is understood and agreed that the seller is privileged to deliver acid of greater or lesser strength than sixty (60) degrees Baume. For any excess or deficiency in such acid above or below sixty (60) degrees Baume, a proportionate increase or reduction shall be made in the price per ton, according to the percentage of sixty (60) degrees acid contained in such

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[4]Tentative change from 3 per cent usually specified. The change is in line with recent studies of colloidal action.

acid of higher or lower degree, as set forth in the table of Manufacturing Chemists Association of the United States.

SEC. 2. Shipments shall be made in Sellers' tank cars, as directed.

CHLORIDE OF LIME OR BLEACH

SECTION 1. Chloride of Lime shall contain not less than thirty-five per cent (35%) of available chlorine.

SEC. 2. It shall be packed in sheet iron drums 700 to 800 pounds per drum.

LIQUID CHLORINE

SECTION 1. The liquid chlorine shall be practically a chemically pure anhydrous chlorine gas.

SEC. 2. Liquid chlorine shall be shipped in steel cylinders provided with suitable valve for controlling flow of chlorine. Each cylinder shall contain approximately from 100 to 150 pounds of chlorine.

ORGANIZATION OF COMMITTEE 12

The following list shows the sub-committees of Committee 12. One change has occurred during the year, namely, the resignation of Mr. John H. Gregory and the appointment of Mr. L. P. Wood, Assistant Engineer, Board of Water Supply, New York City, to fill the vacancy.

Compilation of Existing Standard Specifications	L. P. Wood T. H. Wiggin
Alum Sulphuric acid Bauxite Soda ash Caustic soda Ferrous sulphate Copper sulphate Bleach Liquid chlorine	C. B. Hoover, Chairman Richard Merriman A. V. Graf
Lime	T. Merriman C. B. Hoover T. H. Wiggin
Brass Bronzes Copper Monel metal Nickel steel	T. Merriman T. H. Wiggin
Cast iron (except for water pipes)	W. R. Conard F. A. McInnes
Lead and Jute	F. A. McInnes
Lumber	Richard Merriman
Bolts and Gaskets	L. P. Wood F. A. McInnes

PROGRESS REPORT OF COMMITTEE NO. 18 ON FILTER SAND ANALYSIS[1]

The Committee on Filter Sand Analysis does not feel that it is practicable or desirable to present a report with recommendations during the present year. Therefore, the committee merely submits a progress report intended to draw out discussion.

To stimulate discussion, certain questions that have been raised by members of the committee and others are set forth.

The specific duty assigned to the committee is that of inquiring into methods for testing and recording filter sand. These items can not, however, be intelligently discussed without considering rather fully experiences with the use of filter sand. In this particular it is hoped by the committee that the discussion will be especially extended.

To clear the way for further discussion a short historical sketch of the examination of filter sand follows:

HISTORICAL

At the Lawrence Experiment Station of the Massachusetts State Board of Health, established in 1889 the need was soon recognized for some means of conveniently and accurately determining the size and uniformity of sands and gravels. A method was worked out by Mr. Allen Hazen, then chemist at the experiment station, based on the average actual dimensions of the particles and the use of plottings for showing the characteristics of the materials with reference to filtration.

For large particles, hand picking, weighing and the determination of specific gravity were used to ascertain the range of size.

For small gravel and sand, separations were made with carefully selected sieves. The sieves in turn were calibrated either by direct measurement of the diameters of the particles under a microscope or

[1]Prepared under the direction of Council. The personnel of Committee No. 18 follows: Paul Hansen, chairman, Chicago, Ill.; M. Z. Bair, Little Rock, Ark., G. C. Catlett, Raleigh, N. C., E. S. Chase, Boston, Mass., H. F. Ferguson, Springfield, Ill., G. C. Habermeyer, Urbana, Ill., H. N. Jenks, Berkeley, Calif., P. B. Streander, Darby, Pa., and J. E. Williamson, New York, N. Y.

by counting the last particles to pass a sieve, weighing them and determining their average diameter by a specific gravity method.

For very fine particles, a somewhat empirical method of elutriation with water was used.

For convenience, the results of separations by sieves, hand picking and elutriation were plotted with percentages by weight as ordinates and grain sizes as abscissa usually on logarithmic scales as such scales give a straighter curve.

As a result of observation and experiment at the experiment station, Mr. Hazen concluded that the "effective size" for filtration was that size of grain of which 10 per cent of the material was finer than itself and that the uniformity or non-uniformity could best be measured by a "uniformity coefficient," described as the ratio of the weight of that portion of which 60 per cent was finer than, to the weight of that portion of which 10 per cent is finer than.

Hazen's method of examining sands was so well worked out and the logic of it was so clear that it was generally adopted by engineers and has been almost universally used in the United States ever since.

COMMENT ON HAZEN'S METHOD

Perhaps it has been too blindly used, especially in the acceptance of the definitions of "effective size" and "uniformity coefficients," but this is not Mr. Hazen's fault because he was very careful in defining these terms to refer to his definitions "as a provisional basis which best agrees with the known facts."

The question may be raised (and this is one upon which the committee would like further discussion): Should the effective size be based upon that size of which there is 10 per cent finer than or should some other percentage be chosen?

In his experiments on friction losses in the passage of water through sands, Hazen assumes that sand as used in filtration is uniformly mixed and that filtration takes place throughout the body of the sand bed. This is also reflected in the following statement from the 1892 report.

> The results obtained at Lawrence indicate that the finer 10 per cent have as much influence upon the action of a material in filtration as the coarse 90 per cent. This is explained by the fact that in a mixed material, containing particles of various sizes, the water is forced to go around the larger particles and through the finer portions which occupy the intervening spaces, and so it is this finest portion which mainly determines the frictional resistance, the capillary attraction, and in fact the action of the sand in almost every way.

In only a few cases, as far as the committee is aware, has filter sand been specified on any other basis than the effective size and uniformity coefficient as defined by Hazen. For the Albany slow sand filters, Hazen himself and for the Pittsburg slow sand filters, Morris Knowles specified a more or less complete gradation of sand. For Hazen's specifications, see JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION for 1915, page 509. Knowles' Pittsburg specifications read:

> Not more than 0.5 per cent by weight shall be less than 0.13 mm. not more than 7 per cent less than 0.26 mm. At least 7 per cent by weight shall be less than 0.34 mm., at least 70 per cent less than 0.83 mm. and at least 90 per cent less than 2.1 mm.

This in effect defines the effective size as that size of which 7 per cent is finer than itself.

In the case of rapid sand filters, the process of washing the filter tends to grade the sand bringing the finer particles to the surface where the major portion of the filtration takes place. Furthermore the washing process tends to increase the uniformity of the sand grains thus reducing the uniformity coefficient. This in turn tends to increase the percentage and size of voids. For rapid sand filters, there would seem to be an especially good reason for reducing the percentage of sand below the effective size.

Offsetting the above consideration is the fact that the lower the uniformity coefficient or the more nearly the sand grains are of the same size the more unimportant becomes the percentage below the effective size because a variation one way or the other makes no appreciable difference. The limiting case occurs with a sand having a uniformity coefficient of unity in which case for all practical purposes any grain represents the effective size.

ABRAM'S FINENESS MODULUS

As having a possible application to the examination of filter sand, attention has been called to the work of Prof. Duff. A. Abrams on the examination of fine and coarse aggregates with reference to the effect of grading on the strength of concrete. Prof. Abrams uses W. S. Tyler Company's standard sieves made of wire mesh. These mesh sieves are woven especially for the purpose and correspond approximately to the standards of the United States Bureau of Standards. A nest of screens is chosen in which the clear opening

in each sieve is double the next smaller size and half the next larger; thus the areas of the openings increase approximately in the ratio of squares and the volume or weight (assuming uniform specific gravity) of particles passing increases in the ratio of cubes. These are essentially the same standard screens used in the "Tentative Method of Test for Sieve Analysis of Aggregates for Concrete" of the American Society of Testing Materials.

This gradation of sizes has a certain advantage in that the diameters when plotted on a logarithmic scale give even spaces and thus facilitate an examination or an analysis of curves. It must be borne in mind, however, that the actual diameter of the separated grains will not vary exactly in the geometrical progression of two. The accuracy may be sufficient for ordinary purposes if the sieves are very closely uniform.

Professor Abrams has devised the term "fineness modulus" which is defined as the sum of the percentages of the material coarser than that separated by each sieve divided by 100. Typical analyses and plottings are given in table 1 and the method of plotting is shown in figure 1.

The term fineness modulus gives much the same information concerning a sand as Hazen's uniformity coefficient, but it adds some information regarding the size of the particles inasmuch as the value of the coefficient increases more or less directly with the size of particles. A smooth standard gradation of material might be represented by a straight line on the diagram and the fineness modulus would have a value measured by the area under the line. A larger value than this would indicate a preponderance of large material and a smaller value would indicate a preponderance of smaller material.

Abrams' demonstration that any two mixtures of material used as concrete aggregates and having the same fineness moduli produce the same strength of concrete, other factors such as cement, water, etc. being equal. He also demonstrates that the same quantity of water is required to give maximum strength of concrete with aggregates having the same fineness modulus, other factors being equal. It would appear from this that two sand mixtures having the same fineness modulus would have the same voids or a disposition of particles that might give the same loss of head to the passage of water. This may be worthy of investigation with the apparatus used by Hazen to determine resistance to the passage of water.

From the diagram it would be possible to ascertain the screen separation or the calibrated size of which there is 10 per cent or any other per cent finer than, in order to obtain the effective size as defined by Hazen.

Perhaps the best information that could be obtained from Abrams' method as applied to filter sand analyses would be a statement of the

TABLE 1

Method of calculating fineness modulus of aggregates

The sieves used are commonly known as the Tyler standard sieves. Each sieve has a clear opening just double that of the preceding one.

The sieve analysis may be expressed in terms of volume or weight.

The fineness modulus of an aggregate is the sum of the percentages given by the sieve analysis, divided by 100.

Sieve Size	SIZE OF SQUARE OPENING		SIEVE ANALYSIS OF AGGREGATES—PER CENT OF SAMPLE COARSER THAN A GIVEN SIEVE						
			Sand			Pebbles.			Concrete Aggregate
	Inches	Millimeters	Fine (A)	Medium (B)	Coarse (C)	Fine (D)	Medium (E)	Coarse (F)	(G)†
100 mesh	0.0058	0.147	82	91	97	100	100	100	98
48 mesh*	0.0116	0.295	52	70	81	100	100	100	92
28 mesh*	0.0232	0.59	20	46	63	100	100	100	86
14 mesh*	0.046	1.17	0	24	44	100	100	100	81
8 mesh	0.093	2.36	0	10	25	100	100	100	78
4 mesh	0.185	4.70	0	0	0	86	85	100	71
⅜ inch	0.37	9.4	0	0	0	51	66	86	49
¾ inch	0.75	18.8	0	0	0	9	25	50	19
1½ inch	1.5	38.1	0	0	0	0	0	0	0
Fineness modules.....			1.54	2.41	3.10	6.46	6.86	7.36	5.74

*(Note added at fifth printing, October, 1922). The No. 48, 28, and 14-mesh sieves give the same separation as the No. 50, 30, and 16 now used in the "Tentative Method of Test for Sieve Analysis of Aggregates for Concrete" of the American Society for Testing Materials. The No. 50, 30, and 16 sieves are now used in all our tests.

†Concrete aggregate "G" is made up of 25 per cent of sand "B" mixed with 75 per cent of pebbles "E". Equivalent gradings would be secured by mixing 33 per cent sand "B" with 67 per cent coarse pebbles "F", 28 per cent "A" with 72 per cent "F," etc. The proportion coarser than a given sieve is made up by the addition of these percentages of the corresponding size of the constituent materials.

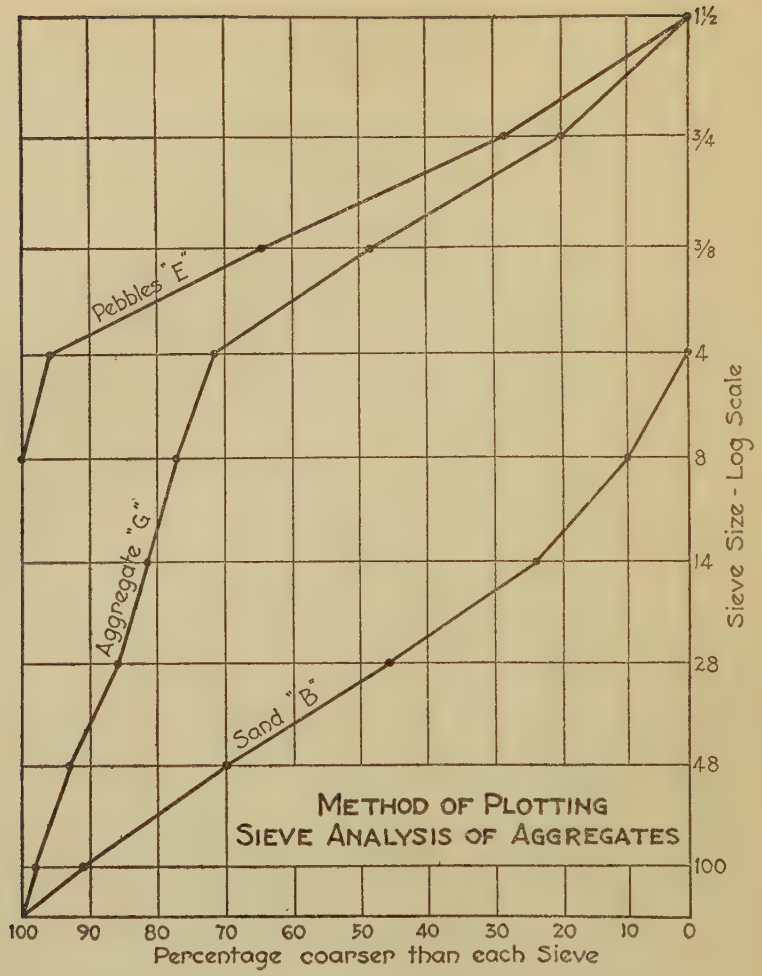

FIG. 1

maximum size and the fineness modulus. To describe the "maximum size," Abrams' formula may be used as follows:

If more than 20 per cent of the aggregate is coarser than any sieve the maximum size shall be taken as the next larger sieve in the standard set; if between 10 and 20 per cent is coarser than any sieve, the maximum size shall be the next larger "half-sieve;" if less than 10 per cent is coarser than certain sieves the smallest of these sieves shall be considered the maximum size.

If it can be definitely shown that the "fineness modulus" can furnish any additional information concerning the behavior of filter sands beyond that now given by Hazen's method, there may be an advantage in adopting it and dropping the term "uniformity coefficient," especially if the use of the fineness modulus gains wide currency in the examination of sands and gravels for purposes other than filtration.

DIAMETER IN MILLIMETERS VERSUS SIEVE MESH

More or less criticism of the Hazen method has been aimed at the use of millimeters in giving the effective size of sand as being beyond the understanding of contractors or alarming to them because implying undue scientific exactness. This practice has gained such currency in the last thirty-five or more years that this apprehension would seem to be somewhat exaggerated.

Nevertheless, some simplicity would undoubtedly result if it were feasible to express the results of sand analysis in terms of separations by standard sieves rather than in terms of average diameters or diameters of equivalent spheres measured in fractions of millimeters. But this must be predicated upon the prior manufacture and general acceptance of standard sieves of a reliable degree of accuracy. It was precisely because of the absence of such sieves that Hazen worked out methods of measuring the size of sand grains and calibrating sieves so that the results of analyses might be expressed in terms of the sizes of sand grains rather than in terms of meshes to the inch or other sieve characteristics. The advisability of a change from the Hazen method, therefore, narrows down to a decision as to whether there is now available a generally accepted, readily available and officially adopted set of sieves.

RELATIVE STANDARDIZATION OF SIEVES

In 1914, Mr. Philip Burgess presented a paper before the Association that was in substance a plea for the adoption of sieve separations to express the analyses of a sand. As considerable discussion developed both in favor and against the proposal a committee was formed to inquire more fully into the subject. The members of this committee were as follows: Philip Burgess (chairman), George W. Fuller and Edgar M. Hoopes, Jr.

This committee did not report until 1918 partly because its members were unable to agree upon any definite recommendations for a revised method of sand analysis and partly because the Committee awaited action on the part of the United States Bureau of Standards in devising specifications for standard sieves as well as concordant action on the part of manufacturers and users of analysis sieves.

Up to 1916 the Bureau of Standards had standardized only two sieves, namely, those having 200 meshes to the inch and those having 100 meshes to the inch. These were used primarily for cement testing.

On April 20, 1917 the Bureau of Standards arranged a conference at Washington including representatives of many engineering and technical societies interested in the adoption of standard sieves. The conference after considering a number of sieve scales adopted a sieve scale as standard and recommended its general use. The committee of the American Water Works Association recommended this standard for use in the mechanical analysis of filter sands but no formal action by the Association was taken. This sieve scale is described in the committee's report as follows:

> The screen scale is essentially metric. The sieve having an opening of 1 mm. is the basic one and the sieves above and below this in the series are related to it by using in general the square root of 2, or 1.4142, or the fourth root of 2, or 1.1892, as the ratio of the width of one opening to the next smaller opening. The first ratio, that is 1.4142, is used for openings between 1 and 8 mm., while the second ratio is used for openings below 1 mm. to give more sieves as required in that part of the scale.
>
> Because of the possible wide range of openings in sieves now manufactured with a given number of meshes of wire per unit length, due to the use of wires of different diameters, and because of the consequent confusion and uncertainty which arise in designating sieves by the number of meshes per unit length, the sieves of this series are designated by the width of the opening in millimeters, as for example a 1.41 mm. sieve, or a 0.36 mm. sieve. The committee recommends that this method of designating sieves be adopted instead of the customary method of designating the number of meshes per inch.
>
> To meet the need for sieves of this series at the present time the committee has included a temporary provision in the specifications for the acceptance of sieves of slightly different mesh and wire diameter than that called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range. This will make possible the use of a number of sieves now on the market in which the ratios of wire diameter to opening are only slightly different from those of the screen scale.

Specifications for standard sieves

Sieves shall be of brass constructed in diameters of 20 cm. (7.87 inches) or 15 cm. (5.91 inches). These are the outside diameters of the bottom of the sieves or the inside diameters of the top of the sieves.

Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of 0.062 mm. sieves, may be twilled until further notice) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame—the joint shall be smoothly filled with solder, or so made that the material will not catch.

The number of wires per centimeter of the cloth of any given sieve shall be that shown in the accompanying table 2 in the second column, headed "Mesh," and the number of wires in any whole centimeter shall not differ from this amount by more than the tolerance given in the fifth column, that headed "Mesh" under the heading "Tolerances." No opening between adjacent parallel wires shall be greater than the nominal width of opening for that sieve by more than the following amounts:

Five per cent of the nominal width of opening for the 8 mm. to 1 mm. sieve, inclusive.

Ten per cent of the nominal width of opening for the 0.71 mm. to the 0.36 mm. sieve, inclusive.

Twenty per cent of the nominal width of opening for the 0.25 mm. to the 0.125 mm. sieve, inclusive.

Thirty per cent of the nominal with of opening for the 0.088 mm. and the 0.62 mm. sieve, inclusive.

The diameters of the wires of the cloth of any given sieve shall be that shown in the third colum of table headed "Wire Diameter," and the average diameter of the wires in either direction shall not differ from the specified diameter by more than the tolerance given in the last column of table, that under "Tolerances" headed "Diameter."

Sieves shall be rejected for obvious imperfections in the sieve cloth or its mounting, as for example, punctured, loose or wavy cloth, imperfections in soldering, etc.

Until further notice, to permit the use of sieves now on the market which have slightly different mesh and wire diameters from that specified above, sieves will be satisfactory if the measurememts of mesh and wire diameters show the resulting average width of opening to be within 4 per cent of the nominal opening of a given sieve, and the ratio of wire diameter to opening of the sieve in question is within 0.03 of that given in the table, in the column headed "Ratio Wire Diameter to Opening" for the 8 mm. to the 2 mm. sieves, inclusive, and within 0.06 of the ratio given for sieves of smaller openings than 2 mm.

Since the submission of the Committee's Report in 1918, the Bureau of Standards has somewhat modified its standards so as to bring them more nearly in accord with manufactured products. These modifications do not relate to the diameters of openings or the

TABLE 2

Standard screens for mechanical analyses of sand

	WIDTH OF OPENINGS	MESH	WIRE DIAMETER	RATIO WIRE DIAMETER TO OPENINGS	TOLERANCES	
					Mesh	Diameter
Metric	8.00	1.00	2.00	0.25	0.01	0.008
Customary	0.315	2.54	0.079	0.25	0.03	0.003
Manufactured	8.05	2.5	0.083	0.26		
Metric	5.66	1.4	1.48	0.26	0.01	0.08
Customary	0.223	3.56	0.056	0.26	0.03	0.003
Manufactured	5.66	3.5	0.063	0.28		
Metric	4.00	2.0	1.00	0.25	0.02	0.05
Customary	0.157	5.1	0.039	0.25	0.05	0.002
Manufactured	4.04	5.0	0.041	0.26		
Metric	2.83	2.75	0.81	0.29	0.02	0.05
Customary	0.111	7.0	0.032	0.29	0.05	0.002
Manufactured	2.82	7.0	0.032	0.29		
Metric	2.00	3.9	0.56	0.28	0.04	0.05
Customary	0.079	9.9	0.022	0.28	0.1	0.002
Manufactured	2.03	10.0	0.020	0.25		
Metric	1.41	5.0	0.59	0.42	0.08	0.025
Customary	0.555	12.7	0.0232	0.42	0.2	0.001
Manufactured	1.42	12.0	0.027	0.69		
Metric	1.00	7.0	0.43	0.43	0.15	0.020
Customary	0.394	17.8	0.0169	0.43	0.4	0.0008
Manufactured	1.01	18.0	0.016	0.41		
Metric	0.71	9.0	0.40	0.56	0.3	0.012
Customary	0.0280	22.9	0.157	0.56	0.75	0.0005
Manufactured	0.72	22.0	0.017	0.60		
Metric	0.50	12.0	0.33	0.66	0.4	0.012
Customary	0.0197	30.5	0.0130	0.66	1.0	0.0005
Manufactured	0.50	33.0	0.0135	0.68		
Metric	0.36	16.0	0.26	0.72	0.6	0.010
Customary	0.0142	40.6	0.0102	0.72	1.5	0.0004
Manufactured	0.36	40.0	0.011	0.79		
Metric	0.25	23.0	0.185	0.74	1.0	0.008
Customary	0.0098	58.4	0.0073	0.74	3.0	0.0003
Manufactured	0.25	60.0	0.007	0.72		

TABLE 2.—*Continued*

	WIDTH OF OPENINGS	MESH	WIRE DIAMETER	RATIO WIRE DIAMETER TO OPENINGS	TOLERANCES	
					Mesh	Diameter
Metric	0.17	31.0	0.15	0.88	1.0	0.008
Customary	0.0067	78.7	0.0059	0.88	3.0	0.0003
Manufactured	0.17	80.0	0.00575	0.85		
Metric	0.125	47.0	0.089	0.71	1.5	0.008
Customary	0.0049	119.4	0.0035	0.71	4.0	0
Manufactured	0.119	120.0	0.0036	0.77		
Metric	0.088	67.0	0.061	0.69	2.5	0.005
Customary	0.0035	170.2	0.0024	0.69	6.0	0.0002
Manufactured	0.0089	170.0	0.0024	0.69		
Metric	0.062	98.0	0.040	0.65	3.5	0.005
Customary	0.0024	248.9	0.0016	0.65	9.0	0.0002
Manufactured	0.061	250.0	0.0016	0.67		

general scheme on which the standards are worked out but to wire diameters and tolerances. The fundamental data on standard sieves now in use by the Bureau of Standards are given in table 3. In this table the sieve number in the first column corresponds approximately to the number of meshes to the inch. The Bureau of Standards, however, lays stress on the necessity of considering diameters of openings and not meshes. The sieve numbers are to be considered as arbitrary designation numbers.

Arrangements were made by the Bureau of Standards to test sieves and to certify and stamp with the seal of the Bureau those found to be satisfactory.

The Committee recommended methods for making separations and determining sizes of separations that are essentially those recommended in the original Hazen procedure.

The committee considered the feasibility of adopting a table of relations between sizes of sieve opening and sizes of sand grains separated by them to be used with standard sieves and presented table 4 as representative of observed facts, but the committee could not reach an accord on factors to be recommended to the Association.

The committee was divided on the question of designating the size of sand grain by giving the sieve opening or by giving the

TABLE 3

United States standard sieve series table of fundamental data, standard specifications for sieves

SIEVE NUMBER	SIEVE OPENING		WIRE DIAMETER		TOLERANCE		
	Millimeters	Inches	Millimeters	Inches	In average opening	In wire diameter	In maximum opening
					per cent	*per cent*	*per cent*
2½	8.00	0.315	1.85	0.073	1	5	10
3	6.73	0.265	1.65	0.065	1	5	10
3½	5.66	0.223	1.45	0.057	1	5	10
4	4.76	0.187	1.27	0.050	1	5	10
5	4.00	.157	1.12	0.044	1	5	10
6	3.36	0.132	1.02	0.040	1	5	10
7	2.83	0.111	0.92	0.036	1	5	10
8	2.38	0.0937	0.84	0.0331	2	5	10
10	2.00	0.0787	0.76	0.0299	2	5	10
12	1.68	0.0661	0.69	0.0272	2	5	10
14	1.41	0.0555	0.61	0.0240	2	5	10
16	1.19	0.0469	0.54	0.0213	2	5	10
18	1.00	0.0394	0.48	0.0189	2	5	10
20	0.84	0.0331	0.42	0.0165	3	5	25
25	0.71	0.0280	0.37	0.0146	3	5	25
30	0.59	0.0232	0.33	0.0130	3	5	25
35	0.50	0.0197	0.29	0.0114	3	5	25
40	0.42	0.0165	0.25	0.0098	3	5	25
45	0.35	0.0138	0.22	0.0087	3	5	25
50	0.297	0.0117	0.188	0.0074	4	10	40
60	0.250	0.0098	0.162	0.0064	4	10	40
70	0.210	0.0083	0.140	0.0055	4	10	40
80	0.177	0.0070	0.119	0.0047	4	10	40
100	0.149	0.0059	0.102	0.0040	4	10	40
120	0.125	0.0049	0.086	0.0034	4	10	40
140	0.105	0.0041	0.074	0.0029	5	15	60
170	0.088	0.0035	0.063	0.0025	5	15	60
200	0.074	0.0029	0.053	0.0021	5	15	60
230	0.062	0.0024	0.046	0.0018	5	15	60
270	0.053	0.0021	0.041	0.0016	5	15	60
325	0.044	0.0017	0.036	0.0014	5	15	60

Note: In order to utilize cloth now on the market, it will be permissible, until further notice is given to the contrary, to use wire whose diameter is within a tolerance of 10 per cent for the first three groups and 20 per cent for the last two groups. Until notice is given to the contrary, the allowable tolerances on average openings will be 50 per cent more than those given in the above table.

mean diameter in millimeters using in the latter case Hazen's method for calibrating sieves. The committee in general felt that further investigation was necessary to reach a conclusion on this point.

Since the report of the Committee on sand analysis in 1918 it does not appear that the standard sieves recommended by the U. S. Bureau of Standards have come into very general use, though firms like the W. S. Tyler Co. of Cleveland, Ohio are prepared to make them. Generally there has been a tendency to adhere to the manu-

TABLE 4

Relations between sizes of opening and sizes of separation of sieves

SIEVE OPENING	MESH	RATIO WIRE DIAMETER TO OPENING	RATIO SIZE OF SEPARATION TO OPENING	CORRESPONDING SIZE OF SEPARATION
mm.	*inches*			*mm.*
8.00	2.54	0.25	1.09	8.72
5.66	3.56	0.26	1.09	6.17
4.00	5.1	0.25	1.09	4.36
2.83	7.0	0.29	1.09	3.08
2.00	9.9	0.28	1.09	2.18
1.41	12.7	0.42	1.10	1.55
1.00	17.8	0.43	1.10	1.10
0.71	22.9	0.56	1.10	0.78
0.50	30.5	0.66	1.10	0.55
0.36	40.6	0.72	1.11	0.40
0.25	58.4	0.74	1.11	0.28
0.17	78.7	0.88	1.11	0.19
0.125	119.4	0.71	1.11	0.14
0.088	170.2	0.69	1.11	0.10
0.062	248.9	0.65	1.20*	0.07

*Ratio assumed for twilled cloth. For plain cloth ratio is 1.11 and separation is 0.068 mm.

facturers standards that most nearly approach those of the Bureau of Standards and the standard sieves manufactured by the W. S. Tyler Co. are in fairly general use especially for the examination of concrete aggregates and they approximate closely the standard of the United States Bureau of Standards.

PHYSICAL, CHEMICAL AND MICROSCOPIC ANALYSIS OF SAND

Within recent years more and more recognition has been given to the close relation between the condition of filter sand and the be-

havior of filters and this in turn has given rise to the periodic examination of filter sand comprising the usual mechanical, physical, mineral and organic chemical, and microscopic analyses.

The mechanical analysis is of value in determining change in size of sand due to losses of fine material during washing and the effect of incrustation due to lime, iron and manganese.

The physical analysis by an observation of color, odor, shape of grains and shrinkage gives considerable information on the condition of the sand beds including incrustation and organic growths.

Mineral chemical analysis brings out the nature of incrusting materials.

Organic chemical analysis would give a measure of the extent of organic growth within the bed and a measure of the effectiveness of cleansing methods.

The recent investigations of John R. Baylis at the Montebello filters in Baltimore have emphasized the importance of microscopic analysis as throwing light on the condition of a filter bed. This gives a measure of the thickness of gelatinous films on sand grains which appear to bear an intimate relation to the behavior of mechanical filters. According to studies by Baylis, a certain amount of this organic growth is necessary to efficient filtration, while too much gives rise to crack formation and clogging.

The committee has not had an opportunity to study and compare methods that have been employed in making physical, chemical and microscopic analyses, but hopes this progress report will stimulate discussion and bring to the committee material which it may use in formulating suggested standard methods.

REPORT OF STANDARDIZATION COUNCIL

The fourth year of activities of the Standardization Council shows sufficient material in hand and available in the early future for the preparation of the first edition of a Manual of American Water Works Practice. Accordingly the Council has requested authority of the Executive Committee for the execution of a contract with the publishers of the JOURNAL, the Williams & Wilkins Co. of Baltimore, for the publication of the proposed manual.

After the material has been prepared, there will be no expense to the Association, unless alterations in the proof result in costs in excess of 10 per cent or the cost of setting up the original composition. All costs of such additional changes in the proof, as is the ordinary custom, will have to be paid by the Association. The publishers agree to pay the Association a royalty of 10 per cent of the price received by them for each copy sold. It is expected that the Council in cooperation with the Publication Committee can get the manuscript completed early in 1925.

As to carrying out the recommendations of our Committee on Standard Methods of Water Analysis for having the next edition of "Standard Methods of Water Analysis" published jointly by the American Public Health Association and the American Water Works Association, a form of contract has been approved by the committees of the two Associations and has recently been put before the respective Executive Committees for official approval. The contract provides for the manuscript to be put in final form acceptable to the committees of the two associations and then be turned over to the general secretary of the American Public Health Association to supervise printing and binding. Copies will be placed on sale in the offices of the secretaries of the two associations at a price to be agreed upon and there is to be an equal division between the two associations both of total disbursements and of total receipts.

During the past year committees have been active in preparing material for reports, but the discussion of the material offered by and through the committees has been much less extensive than is

necessary in order to stimulate the committees in their activities. Indeed, in order to get the manuscript in satisfactory form for the proposed Manual, it is highly important to secure the benefits of extended discussion, which it now seems can be best managed by having certain topics discussed at meetings of the local sections in accordance with a program to be developed jointly by section committees, the Publication Committee and the Standardization Council.

With sessions only four days per year for an Association dealing with the many topics involved in water works practice, the conviction has become most pronounced that the growth of the Association demands new machinery for securing adequate discussion.

We shall review briefly the status of activities of our several committees.

COMMITTEE 1. STANDARD METHODS OF WATER ANALYSIS

The status of this committee's activities is shown in the JOURNAL, September, 1923, page 861. Each member of the committee has received definite assignments of topics for individual study and investigation. The work of coördinating views with the committee of the American Public Health Association is to be paralleled in some particulars by cooperative work with a committee of the Society of American Bacteriologists.

COMMITTEE 2. STANDARDS FOR SATISFACTORY DRINKING WATER

The activities of this committee are controlled by the Advisory Committee on Official Water Standards of the United States Public Health Service of the Treasury Department. Much information on this subject was gathered by this committee and presented at the Detroit convention and summarized in the JOURNAL, September, 1923, page 884.

COMMITTEE 3. PRACTICABLE LOADINGS FOR PURIFICATION PROCESSES

To this committee has been assigned one of the leading topics in the field of water treatment. The committee has prepared ample material on important topics for wide and fruitful discussion.

COMMITTEE 4. COLLOID CHEMISTRY IN RELATION TO WATER PURIFICATION

This committee reported in the JOURNAL, March, 1922, page 273, a summary of prevailing views as to the applicability of hydrogen

ion tests and the practical benefits arising from information so secured. To carry the information beyond this point, the subject must have comprehensive yet detailed discussion by committee members and other interested workers.

COMMITTEE 5. WATERSHED PROTECTION

This committee provides valuable information for discussion both in its report in the JOURNAL for May, 1923, page 453 and in the JOURNAL for May, 1924. Experiences in the protection of the Catskill Watershed of the city of New York will also be offered in a separate paper.

COMMITTEE 6. INDUSTRIAL WASTES IN RELATION TO WATER SUPPLY

Information of much practical benefit was offered by the committee at the last two conventions and summarized in the JOURNAL for May, 1923, and further information indicating experiences in remedial steps appears in the JOURNAL for May, 1924. This topic is particularly one upon which discussion is needed to bring out information of importance, not known as widely as should be the case to those in charge of water supply works.

COMMITTEE 7. PUMPING STATION BETTERMENTS

This committee continues to supply articles on new equipment and improved arrangements and operating schedules. The papers for the year include information on the selection of auxiliaries for steam-operated stations, in the March, 1924, JOURNAL, and the contribution on the selection of motor-driven pumps at Kansas City described in the JOURNAL for May, 1924.

COMMITTEE 8. PHYSICAL STANDARDS FOR DISTRIBUTION SYSTEMS

This committee offers a paper by V. Bernard Siems and D. Benton Biser on "Fire Protection Requirements in Distribution System Design" in the JOURNAL for January, 1924, for discussion, and it is expected that fire protection aspects will be discussed by members who specialize in such topics.

COMMITTEE 9. STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND SPECIALS

This committee is dealing with the question of improved coating for pipe and awaits information from the manufacturers. Lack of funds restrains activities in carrying out experimental work needed to formulate improved standards.

COMMITTEE 10. STANDARDIZATION OF SERVICES

This committee offers for discussion, a contribution on the Action of Water on Service Pipes, in the JOURNAL for May, 1924.

COMMITTEE 11. SANITARY FOUNTAINS

A final report has been prepared appearing in the JOURNAL, March, 1924. It recommends the adoption of specifications as stated and the promotion of information relative to more adequate regulation and supervision of this feature.

COMMITTEE 12. TESTING OF WATERWORKS MATERIALS AND SUPPLIES

This committee offers for discussion several topics, including proposed specifications for chemicals required for water purification, as set forth in the JOURNAL, May, 1924.

COMMITTEE 13. METHODS AND RECORDS OF WATER WASTE CONTROL

This committee made a comprehensive report, printed in the JOURNAL, May, 1923. This report awaits further discussion and especially response to the request for information made by the committee in the JOURNAL for January, 1924. As soon as the committee receives the benefit of the discussion needed, it will prepare its final report.

COMMITTEE 14. COMMITTEE ON METER RATES

The final report was accepted by the Association at the Detroit convention, as stated in the JOURNAL, September, 1923.

COMMITTEE 15. PRACTICAL STANDARDS OF RULES AND REGULATIONS OF RELATIONS BETWEEN WATERWORKS AND CONSUMERS

This committee has gathered a fund of information on this subject, which it is now engaged in condensing for publication.

COMMITTEE 16. ESSENTIAL DATA FOR WATER RECORDS AND REPORTS. (A) MUNICIPAL PLANTS; (B) PRIVATELY-OWNED PLANTS

This committee has prepared forms for records and reports which will serve as an excellent basis for promoting discussion on how to improve forms earlier recommended and in use by many water works. This undertaking requires coördination with the representatives which, at our request, were appointed by the New England Water Works Association as well as with the activities of other committees appointed by the Standardization Council.

COMMITTEE 17. STEEL PIPE LINES

This committee has not yet sent material to the Council for its consideration.

COMMITTEE 18. FILTER SAND, TESTING AND RECORDING

This committee offers its first progress report for discussion; it will be found in the JOURNAL, May, 1924.

While the most important feature to stress by Council is to urge the support of the Association to discussion of reports of these committees, it is a pleasing task for the Council to record its appreciation of the active work done by and for the great majority of its committees. As was anticipated some of the members have not been able to render the service expected and, regardless of cause, it will be necessary to make some changes in personnel following the next convention.

The personnel of Council during the fourth year of service has been as follows:

Chairman, George W. Fuller, New York; George A. Johnson, New York; Frank A. Barbour, Boston; Edward Bartow, Iowa City; W. W. DeBerard, Chicago, and Malcolm Pirnie, Secretary, New York.

A DEVELOPMENT PROGRAM FOR THE AMERICAN WATER WORKS ASSOCIATION

By George W. Fuller[1]

Instead of a presidential address, the writer proposes to review somewhat briefly some of the more important features which have come to his attention during the year when he has had the honor of being the president of this Association.

The past year has been one of substantial growth in many ways. The membership in good standing on April 1, 1924, was 1936, a net increase for the fiscal year of 224, which compares very favorably with any previous year.

The resignation of John M. Diven, our active secretary, has been the principal event. At a meeting of the Executive Committee, January 18, 1924, he was made secretary emeritus,but since February 1 he has continued as advisor to Mr. W. M. Niesley, and in helping the Association in every way feasible within the time at his disposal.

One who has not been an officer of this Association cannot possibly appreciate the benefits which have been derived by the organization from the activities of Mr. Diven. He was president in 1892; secretary and treasurer from 1902 to 1912; secretary and editor from 1913 to 1916; and secretary from 1917 to February 1, 1924. This period of unflagging service on his part was during one of limited resources for a struggling association. It is significant of the man's interest in this society that every item of office equipment in the office of the secretary, with the exception of one typewriter, has been furnished by him, at his own expense. From all over the country requests have come from the members that some recognition be given to Mr. Diven to record their appreciation of his services, in addition to the formal resolutions adopted by the Executive Committee, as set forth on page 490 of the Journal of March 1924. It is with great pleasure that the officers have arranged for a Testimonial Dinner to be given to Mr. Diven on the evening of May 19, 1924.

[1]Retiring President, American Waterworks Association, 1923-24. Consulting Engineer, New York, N. Y.

The offices of the Secretary at 153 West 71st street, which were established in 1919, when downtown offices in New York were unobtainable, were given up on March 1, 1924. This was caused primarily by notice of increased rent. Two small rooms, numbers 1012-13 at 170 Broadway, were rented until May 1, 1925. They have been fitted in a modest way for carrying on the affairs of the Association.

The finances of the Association are in a sound condition. The budget for the past fiscal year, $23,000, was not all used, according to the unaudited figures now available, largely on account of the saving in the estimated expenses for committee work. The actual disbursements were $21,915.27 as compared with total income for the fiscal year of $26,117.31. This left us on April 1, 1924, with a cash balance of $4,202.04 as compared with a cash balance of a year ago of $3,934.40. The invested funds of the Association consist of $12,000 of United States and Canadian Government bonds.

The JOURNAL for the year 1923 consisted of a volume of 1187 pages, issued in six numbers. The quality of the material reflects credit upon the Association and particularly upon the committees and the editor. It attracts favorable attention throughout this country and abroad.

The most serious difficulty with the JOURNAL is that, with a printing budget of $10,000, it is not possible to print all the material that comes to the Publication Committee, which is furthermore in the embarrassing position of not being able to invite papers from the local section meetings as should, and would be done, if funds for printing them were available.

In the beginning of this year there were 37 papers in the hands of the editor, exclusive of those committee reports or papers in the hands of the Standardization Council and the Publication Committee for the convention in May of this year.

The work of the Standardization Council has developed to a stage where the reports of its committees need further discussion in order to bring out their value and supplement them with comments widening their field of usefulness. A serious situation confronts the Association in this problem of developing a program by which adequate discussion may be secured. This is particularly important for the preparation of material needed for the proposed Manual of Practice for Water Works, described in the report of the Standardization Council.

It is not feasible to get needed discussion during the four-day convention held once each year. It is imperative that local sections be called upon to discuss committee reports and test their soundness or weakness by the judgment of members of this Association throughout the entire country. This can be arranged by coördinating the efforts of the Standardization Council, the central Publication Committee and the local Program Committees for the various local sections. This must be done without delay if the proposed Manual is to be sent to the printer during the coming year.

In earlier years, limited finances curtailed many activities. Fortunately that burden is not so pressing now with increased membership and with the increase in advertising rates and in number of advertisers as a result of activities during the past year.

It is estimated that income from operations during the coming fiscal year will amount to about $26,000 which with a $4000 cash balance would make $30,000 available for budget requirements without drawing on the permanent funds of the Association. Indeed, several believe that increased growth of the Association would make feasible a budget in excess of $30,000.

Our publications are now becoming too bulky to be bound as a single annual volume and the Publication Committee is seriously considering issuing eight numbers of the JOURNAL per year in two volumes of four numbers each. This it is feasible to do by increasing the printing budget from $10,000 for the past year to about $13,500. There will be some added expense, but it will afford the Association the opportunity of deriving more income from advertising, for our rates are such that many of our advertisers would undoubtedly wish to utilize their advertising space in eight rather than six numbers per year.

As to a Decennial Index, the indications are that this is not needed by more than about three or four hundred members. As its net cost would exceed some $2000, it is thought best to put available funds into the increased number of journals per year, particularly as that seems necessary in order to develop the discussions insisted upon by the Standardization Council before it releases material for he propo sed Manual.

COÖPERATIVE UNDERTAKINGS

The report of the Standardization Council shows that progress has been made in the matter of Standard Methods of Water Analysis

in undertaking the next edition jointly with the American Public Health Association.

Along this branch of our activities practical plans are under discussion for coöperating with the Society of American Bacteriologists. The same is true of coöperative committee work in the matter of purification of boiler waters in conjunction with the work now in hand by the National Electric Light Association.

Steps have been taken to establish gradually more practically effective coöperation between the American Water Works Association and the National Fire Protection Association on matters of common interest and along lines of effective mutual benefit.

The American Committee on Electrolysis has not been particularly active recently and resumption of activities depends essentially on whether the 11 participating associations, including the American Water Works Association, are agreeable to continuing this committee and a research sub-committee and to provide the latter with adequate funds, meaning a pledge from our Association to contribute $2500 per annum for two years. Messrs. E. E. Minor and N. S. Hill, Jr. are in favor of continuing this joint undertaking by having it endorsed by the Executive Committee at the May meeting and with the understanding that the needed funds will be arranged for by our representatives through subscriptions by interested water companies and city water departments. I endorse the judgment of Messrs. Hill and Minor.

The New England Water Works Association has promptly responded to invitations to appoint representatives on the committees of our Association, particularly on Water Meters, Meter Rates and Essential Data for Water Records and Reports. Your president believes that these coöperative arrangements should be continued and strengthened along lines of mutual benefit to all concerned.

COMMITTEE REPORTS

Most of the committees not operating under Standardization Council seem to have proceeded as far as they are able to do pending the development of new evidence or new circumstances surrounding their activities.

In regard to the Committee on Standard Form of Contract, their activities have still continued in conjunction with representatives of other Associations. Their progress report was presented a year

ago and real benefit has been derived from its use in preparing the forms of contract in use on the water extensions and betterments at Kansas City and elsewhere.

All of these committees should be continued with the understanding that they are to report their accomplishments as promptly as as new developments occur.

REORGANIZATION TO PROMOTE DISCUSSION

From what is said above, it is clear that the Standardization Council will proceed with the proposed Manual of Water Works Practice, if committee reports and other material are adequately discussed during the coming year, but not otherwise.

Fortunately, the financial affairs of the Association permit the central organization to print discussions developed by the meetings of local sections: and can now provide for at least some stenographic reports of the discussions at section meetings. Therefore it is desirable to have closer coöperation between the Standardization Council and the central Committee on Publications on the one hand, and those in charge of local section meetings, on the other hand. This would be a decided step forward, and should bring added strength to the Association through the interest in its general affairs by members who are seldom able to attend the annual conventions.

The use of Monday of convention week for group and committee meetings will do much toward crystallizing views as to procedure along many lines of activity. Where necessary, stenographic services will be provided for committees and groups ready to prepare and submit to the Association formal statements on pending matters of importance originating either with the officers of the Association, or developing from views exchanged at round table talks.

These steps are perhaps scarcely to be designated as reorganization steps, for they are simply the normal outgrowth of what has been occurring for several years, but with progress hampered through inability of the central organization to provide facilities, such as stenographic services, for various detached meetings, and particularly to coördinate efforts between the central officers and those in local charge of section meetings, group meetings or committee meetings.

NATIONAL DIVISIONS

While development along the lines above indicated will be of real benefit in making the Association grow and retain its place as the leading organization of its kind in this country, it does not deal with two other difficulties.

One of these relates to the fact that the programs of the annual conventions for some time have been materially overcrowded and that there has been insufficient time for discussing the superabundance of good material offered.

The second difficulty with the central organization is that responsibility for its accomplishments in the past has all fallen upon the shoulders of too few individuals.

Coördination between the central offices and the local sections throughout the country will remedy past difficulties in part, but they will not deal adequately with the overcrowded programs at the annual convention.

Experience has demonstrated, as at the Detroit convention, that it is perfectly feasible to conduct two enthusiastic meetings at the same time; one dealing with purification matters and the use of laboratory methods for controlling their performance and the other group dealing with the more practical subjects from the viewpoint of the superintendent.

It is along that line that the Association must develop through the formation of national divisions or groups, having special interest in certain branches of water works practice.

To put this suggestion into effect is not particularly simple because of the wide diversity of viewpoint from practical experience to be found among our membership and with the perfectly human viewpoint by each group that their own activities are of outstanding importance.

There is no reason why the superintendents should not be offered full facilities for conducting meetings dealing with topics of special interest to them. Correspondingly, there is no reason why laboratory men should not have an opportunity at annual conventions to discuss matters of a strictly laboratory nature and then, in conjunction with other groups of members, participate in the discussion of topics related to the purification of water by natural agencies or by artificial methods and devices.

For some time there has not been great progress made in advancing a better understanding between fire protection engineers and agencies

and the waterworks men. This situation is unfortunate and will never grow better until opportunity is afforded to have the two groups of men get better acquainted and to discuss things with a view to coördinating opinions, harmonizing practical procedures and establishing a feeling that each group is endeavoring to make progress along the lines which will be of mutual benefit.

With approval of the Executive Committee at its meeting on January 18, 1924, your president appointed three committees to deal respectively with the development of more effective machinery and organization for increasing discussion of committee reports and of papers at the annual conventions. At the Executive Committee meeting discussion related to the establishment of three national divisions, as follows:

1. Plant Management and Operation Division.
2. Water Purification Control Division.
3. Fire Protection Division.

Discussion of these matters by correspondence has been adequate to reveal only the view that the matters should come up for thorough discussion at the next convention.

NEED FOR AVOIDING ENCROACHMENT ON THE FIELDS OF OTHER NATIONAL ORGANIZATIONS

Since the war it has been apparent that several of the national technical and professional organizations have spread out in activities somewhat different than hitherto. The result is in some instances an unfortunate tendency to break away from the special fields earlier occupied and to duplicate the effort and scope of activities of others, even to the point of making what might be called encroachment on the well established fields of other organizations.

It is our thought that the activities of the American Water Works Association have been set along fairly definite lines, including the activities of its different groups from the administrative superintendent to the laboratory man, who seeks to use his technical knowledge as a means of controlling more effectively the arrangements in use for providing water of satisfactory quality.

We are thoroughly in accord with the policy of coöperation with other organizations dealing with matters of common interest. We think, however, that it is necessary for this Association to exercise care in seeing that it does not unreasonably encroach upon the fields

of others and at the same time use its influence to prevent other organizations encroaching upon the activities relating to water works practice, particularly from the standpoint of those who day by day are occupied with the operation of this type of utility in its various ramnifications.

NEED OF AMENDING CONSTITUTION

This is a subject which will be discussed by the Executive Committee at the May meeting. It has in hand already the creation of nine rather than six districts as at present and the election of three instead of two trustees each year.

Another point is that we have a secretary emeritus who occupies that position now solely as an office title, but who by Constitution should have created for him such an official title. In the present instance, such an office should carry a membership on the Executive Committee in order that the benefits of Mr. Diven's long experience may be made available to the management of the Association as long as he is able to help us.

As to membership, Article III, Section 3, provides that an Active Member may be "any qualified person engaged in the advancement of knowledge relating to water supplies in general." Under Section 4, there should be a corresponding clause added to provide for Corporate Members, since we have recently taken in quite a number of state departments of health, fire insurance bureaus and industrial corporations maintaining relatively large water supply works for industrial or domestic purposes or both.

The selection of a place for the next convention has developed into a time-consuming farce which frequently does not represent the wishes of the membership. A majority vote can seldom be polled on the first ballot for one city, so that on the second ballot, limited to the two cities receiving the highest votes on the first ballot, the usual result is a scramble which may or may not record the real wish of the members present. The time has come when convention cities should be selected by the Executive Committee on the advice of the Convention Committee and preferably with a rotation to facilitate the attendance of members in different sections of the country.

The management of the Association in respect to coördination between the efforts of the central officers and those of sections or divisions should be clearly specified with reconsideration of the funds

which may be made available for the meetings of local sections or of national divisions if such should prove desirable or necessary in the opinion of the Executive Committee.

ACKNOWLEDGMENTS

I wish to take this opportunity to indicate my great appreciation of the coöperative effort of the officers and committees of the Association, without whose support little of our progress during the year would have been possible.

DISCUSSIONS

SELECTION OF AUXILIARIES FOR STEAM GENERATING PUMPING STATIONS[1]

While the experience of the writer in connection with pumping stations has been very limited, it would seem that practically all of the broad principles underlying the design and operation of steam electric generating stations might be applicable, particularly in so far as these principles cover the operation of the auxiliary apparatus within the plant. It would seem that the only real differences between the pumping station and the electric generating station are; first, the substitution of a pump and its speed reduction gear in place of the conventional electric generator; and second, the fact that it is undoubtedly often necessary or desirable to reduce the speed of the pump somewhat to take care of the varying demand for water. With the general increase in price of fuel as well as the increase of load factor on the newer generating stations and water pumping plants, increased capital cost can be justified by the attendant gains in economy. As these gains are mainly to be realized by increasing the pressure and temperature of steam supplied and expanding this steam to the maximum vacuum, it becomes more and more evident that the steam turbine will replace the reciprocating engine. Inasmuch as the temperature of the water handled by the main pumps is relatively cool, even in the more temperate climates, it is possible to realize, on the average, higher vacuum than is commercially obtainable in the larger electric generating stations. As this higher vacuum, as well as higher temperature of steam, can be used to greater advantage in steam turbines it would seem that the reciprocating engines should not be generally used in the larger stations.

The use of the steam turbine makes possible the fuller utilization of the various regenerative cycles which are coming into very general use in the modern central stations. In those plants of sufficient size to justify pumping units necessitating drives of from 400 to

[1]See paper by F. G. Cunningham, JOURNAL, January, 1924, page 341.

800 h.p., it would seem entirely practicable to use a steam pressure of at least 300 pounds gage and a total temperature of 600°F. For units larger than 800 h.p. one should easily be able to justify the use of steam at 375 pounds pressure with a total temperature of 700°F. Standard turbine units as built by any of the larger turbine manufacturers are designed for use under these maximum pressures and temperatures.

Where higher pressures and temperatures are resorted to, one is justified by going to stage-bleeding of the turbine which for smaller units should be limited to two-stage and for larger units three-stage bleeding where no economizers are to be used. Where the use of economizers is contemplated it is improbable that the use of more than two-stage bleeding can be justified, under which condition steam should be bled at such points as will most economically permit of the feed water being admitted to the economizers between the temperature of 200 and 220°F. Where no economizer is used one is justified in bleeding steam from the main turbine to heat the feed water, certainly to within 100° of saturated steam temperature. Where this practice is carried out the flue gas temperatures can be readily lowered to such a point as will produce an overall boiler efficiency of 80 per cent by the use of air pre-heaters, it being borne in mind that if boilers are to be fired by under feed stokers the air temperatures should probably not exceed 300°F. Where hand firing, oil, or pulverized coal is used, air temperatures up to 400°F. should cause no trouble. There are at the present time actual installations used in firing oil stills in which air temperatures approximating 500°F. have been used with success.

The use of high pressure, high temperature steam makes it highly undesirable to use any form of steam drive for auxiliary apparatus other than the air pumps. For air removal pumps there can be no choice from the standpoint of economy, reliability and maintenance cost in the use of other than the steam jet type, equipped with surface type inter and after condensers. The use of small turbines as generally built for non-condensing service on high temperature steam has been very unsatisfactory. This means that under this condition one is committed to the use of electric drive for auxiliaries unless some satisfactory arrangement can be made for the use of hydraulic drive. As between the use of electric and hydraulic drive the most efficient operation will undoubtedly always favor the former.

It now becomes necessary to provide a reliable source of auxiliary power which can undoubtedly be most satisfactorily and economically furnished by directly connecting a generator to each of the main pump shafts. These generators need normally be of only sufficient capacity to take care of the auxiliaries for each main unit, although one might feel justified in having them of sufficient capacity to supply power to the auxiliary drives of two main units, thereby insuring auxiliary power in the event of trouble in one of the direct connected generators; trouble of this nature, however, is exceedingly improbable. Where the main units are operated at or near constant speed, an A.C. auxiliary generator may be used, however, when it is considered that practically all of the auxiliary apparatus in connection with each unit is susceptible to increases in economy when the speed of the auxiliary drive is reduced as the load on the main turbine is reduced, one would be justified in using a D.C. generator and D.C. variable speed motors where the necessary range of speed variation may be obtained by field control. Where the speed of the main unit varies through a considerable range, the use of the D.C. auxiliary generator is obligatory as it may be equipped with a suitable voltage regulator to maintain a uniform voltage at the generator terminals throughout the entire speed range of the main turbine. Units of this type are especially reliable, as it would only be necessary to use a standard type of direct current generator of very moderate capacity, operating at a very satisfactory speed. The record of such units is all that can be desired and far exceeds that of the small steam turbines in reliability. It gives a very high economy as power is being obtained from the main turbines which is the most economical piece of apparatus in the station. The combined efficiency of the motors and the generator should be at least 85 per cent which means that power at the main turbine shaft is supplied to the shafts of the auxiliary apparatus at an efficiency of 85 per cent. This arrangement is extremely reliable as its reliability is almost entirely dependent on the reliability of the main pump drive, and if the main turbine fails the auxiliary power is not needed. It is very simple, all of the controls can be easily grouped at one central point, everything is readily accessible and where the motors are equipped with ball bearings there should be practically no maintenance, and the efficiency of the auxiliary power supply and auxiliary drives would be sustained at their original figure. The generator and motors will be particularly durable and should beyond doubt outlive the main apparatus.

It is only necessary to provide some form of drive to take care of starting up the plant when it is originally built, or should it ever become necessary to shut it down cold. This can best be taken care of by a single steam driven house turbo generator of sufficient capacity to put one main unit in service. This unit may be of slow speed and poor economy as it may reasonably be expected that it will not be called upon to operate more than a few hundred hours during the life of the plant.

While the above plan may seem revolutionary and may at first glance seem to be somewhat impracticable, a careful analysis of the factors involved will satisfy the most skeptical as to its reliability, economy, simplicity and general adaptability. It has stood the test of the scrutiny of a number of experienced and careful designers of large central station developments. It is now being installed on a 40,000 kilowatt development and has been adopted for a new development of 120,000 kilowatts in Baltimore and will very shortly be in service in at least one other large central station plant in the United States.

A. L. Penniman, Jr.[2]

I question whether the paper[1] by Mr. Cunningham has sufficiently stressed the advantages of motor driven auxiliaries for use in steam operated pumping stations, and I am quite sure that Mr. Cunningham has very much understated the reliability of motor driven auxiliaries for use in pumping stations. Few classes of equipment require a greater degree of reliability than do the auxiliaries of a large steam electric generating station. The trend at the present time in the design of new generating stations is all in the direction of eliminating the small steam driven auxiliaries and substituting in their place motor driven auxiliaries. The reasons for this trend should be of interest to the man who is designing a steam operated pumping station, as to some extent the same problems are to be faced in the design of a steam operated pumping station which supplies water to a city water system as have to be dealt with in connection with the design of a steam electric generating station.

There has been a general feeling in the past on the part of steam station engineers that for those auxiliaries requiring the maximum

[2] General Superintendent, Consolidated Gas, Electric Light and Power Co., Baltimore, Md.

degree of reliability, turbine drive or steam engine drive should be used in all cases. As steam pressures and steam temperatures have been increased, it has been more and more difficult to design small turbines and engines for auxiliary drive which would operate satisfactorily with the higher steam pressures and temperatures. Operating troubles and high maintenance in connection with these auxiliaries have increased rapidly as higher steam pressures and temperatures were used. In connection with many of the steam driven auxiliaries it was necessary to insert a reduction gear between the turbine and the pump or fan which the turbine was driving. It is coming to be pretty generally recognized by steam station engineers that reduction gears are good things to eliminate wherever possible. Another factor working in the same general direction has been recognition of the advantages of variable speed drive in connection with the operation of many of the auxiliaries. This variable drive is best obtained by means of a direct current motor. It may be obtained in connection with a steam turbine, a steam engine, or a water turbine, but it is well to bear in mind that the efficiency of a steam turbine or a water turbine drops off very rapidly as the speed is decreased and the ratio of blade speed to steam speed or water speed is changed. This drop in efficiency actually defeats one of the main objects of variable speed drive, which is a proportioning of the power required for the auxiliaries to the load which is being carried by the station.

It is well to bear in mind that in connection with forced or induced draft fans in the boiler room, and in connection with circulating pumps in connection with the surface condensers, the speed of the auxiliary may be varied almost directly with the load which is being carried by the main equipment, a boiler in one case and a turbine in the other. The shaft horse power delivered to the auxiliary varies as the cube of the speed. Now, if such an auxiliary, whether it be a forced draft fan, an induced draft fan or a condenser circulating pump driven by means of a variable speed direct current motor with feed control, the electrical input to the motor will vary as the cube of the speed. The efficiency of this motor is almost constant throughout a reasonably wide range of speed variation. Another alternative is to drive such auxiliaries by means of variable speed, wound rotor induction motors. In this case, however, the efficiency of the motor drops off as the speed is decreased. Actually, this will result in the electrical input to the wound rotor induction motor varying as the square of the speed, although the shaft horse power

output of the motor to the auxiliary will vary as the cube of the speed. It is probable that, even in connection with the wound rotor induction motor, the average efficiency throughout the range of speed variation required for the auxiliary will be very much better than will be the efficiency of the steam turbine or the water turbine. Another factor which is causing the displacement of steam driven auxiliaries by motor driven auxiliaries in steam electric power stations is the desire on the part of steam station men to do away with all small steam piping and the multitude of small steam valves in connection with which a good deal of maintenance work has to be done. Obviously, this problem of high maintenance and steam leakage in connection with small valves and small steam piping becomes more acute as the steam pressure and steam temperature are increased

While fully realizing all the factors referred to above, engineers responsible for the design and operation of steam electric generating stations were unwilling to go to the use of motor driven auxiliaries until they would be assured that these motor driven auxiliaries would be reliable. Several different solutions have been worked out to insure the reliability of power supply for the motor driven auxiliaries. The steam driven house turbine appeared a few years ago to be one of the most promising solutions, and is still being used in connection with a number of the large steam generating stations which are being built. Another solution which seems even more promising, however, is the use of a separate generator, either A.C. or D.C., on the same shaft with the main turbine and the main generator; and it is this arrangement which seems to me to offer the best solution for the operating problems which are met with in connection with the steam pumping station.

I am assuming that we have under consideration a steam pumping station of moderate size, in connection with which the main pumps will be driven by means of steam turbines which will be at least 1000 h.p. in capacity. I believe that the most satisfactory arrangement in connection with such a station will be as follows:

Each of the main turbine driven pumps should be equipped with a direct current generator mounted directly on the end of the pump shaft. This direct current generator would run at the same speed as the pump, but should preferably deliver this power at a voltage of 250. All of the auxiliaries in the station, with the exception of the air removal pumps, should be driven by means of direct current motors. The

circulating pumps, the boiler feed pumps, the stoker motors and the motors driving the forced and induced draft fans should be arranged for a moderate variation in speed by a field control. No fuses should be used in any of the auxiliary circuits. Relays, if used at all, should be set high so as to function only in connection with the segregation of defective apparatus from the rest of the auxiliary system. In the event that there are two or more main pumping units in the station, it will be advisable to divide up the auxiliaries into two groups and drive each of the two groups by means of the direct current generator in connection with one of the two pumping units. In this way, any trouble which arises in connection with a piece of auxiliary equipment will at the most cause a disturbance in connection with the other auxiliaries which are supplied with power from the one generator tied in with that particular circuit.

It will be necessary to make a provision for starting up the station in the event of a total shut down, or in the event that the station is to be started after it has been out of service and cold for some time. Two possibilities suggest themselves in connection with this layout. One is to install a storage battery which will supply power to the auxiliaries during the period that steam pressure is being raised in the boiler house and the first one of the main pumping units is being brought up to speed. It is well to bear in mind that vacuum can be established preparatory to bringing the turbine up to speed with the use of very little auxiliary power. That is, under this condition of operation, the circulating pump may be operated at approximately 50 per cent of its maximum speed. A second solution for the same problem is to install a small steam driven direct current generator which will supply power for the auxiliaries during the period that the station is being started up. The turbine or engine driving this auxiliary direct current generator may be non-condensing and exhaust to atmosphere, as it will be in operation at a very small per cent of the total hours in the year. Provision will be made so that power may be supplied to the auxiliaries by means of this generator during the period that they are being started up. This latter arrangement has the disadvantage that it is necessary to establish steam pressure in the boiler house before the steam driven auxiliary generator is available for use. Of course, this same disadvantage is inherent in all steam driven auxiliaries. The first arrangement which I suggested, in which a storage battery is used for supplying power to the auxiliaries while the main equipment is being brought up to speed,

has the advantage that it is not dependent on the establishment of steam pressure in the boiler house. The stoker motors and the forced draft fans could be operated, taking power from the storage battery during the time while the steam pressure is being established.

In general, I think it will be found that the speeds at which the main pumps in good sized steam driven pumping stations are operated will be suitable for the operation of direct current generators mounted on the shaft with the main pump. These direct current generators will be quite similar in character to the direct connected exciters which have been used for a good many years in connection with turbo-generators, as a means of supplying the field excitation for

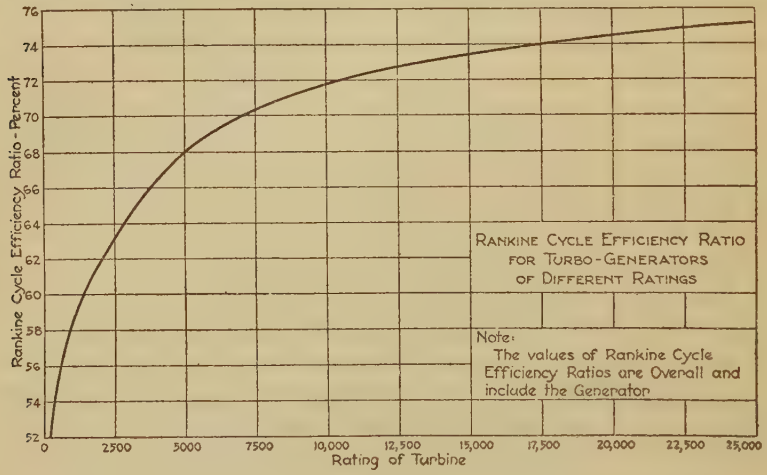

Fig. 1

the main generator. Few pieces of equipment in power stations have given more uniform satisfaction and have a better record for reliability than these direct connected exciters.

The question may be raised—"How do you expect to heat the feed water, if all of the auxiliaries are to be driven by means of direct current motors deriving their power from a generator mounted on the shaft of the main pumping unit?" The answer to this is, that we will bleed steam from the turbine driving the main pump. The Rankine Cycle efficiency ratio of this main pumping unit will probably be of the order of 60 per cent. The Rankine Cycle efficiency ratio of small turbines which would be used for driving the auxiliaries is very much lower. I am giving herewith a curve, figure 1, which

shows the over-all Rankine Cycle efficiency ratio for turbo-generators of different sizes. Bearing in mind that the Rankine Cycle efficiency ratio is the actual useful work performed by the turbine expressed as percentage of the useful work which would be performed by an ideal turbine having no losses, it is to be seen from this curve that the small turbines which would be used for driving auxiliaries must in the nature of the case be quite inefficient. The ideal thing, therefore, is to generate all the power by means of the prime mover which has the highest Rankine Cycle efficiency ratio, and that prime mover happens to be the main turbine which drives the main pump. The efficiency of the direct current generator which supplies power to the auxiliaries will be of the order of 92 per cent, and the efficiency of the motors which drive the auxiliaries will be of the order of 89 per cent, so that actually 82 per cent of the total power delivered by the shaft of the main turbine to the direct current generator will in turn be delivered as shaft horse power available for driving the auxiliaries.

In figure 2 I am showing a layout which I believe is well adapted for use in connection with the pumping station having one or more centrifugal pumps driven by means of steam turbines having a capacity of approximately 1000 h.p. each. I have indicated that steam will be bled out of the main turbine at two different pressures—8 pounds per square inch absolute and 36 pounds per square inch absolute. This steam will go to small closed heaters through which the condensate from the main condenser will be circulated. As the steam passes through the first closed heater, it will be raised to a temperature of 178°. As it passes through the second closed heater it will be raised to a temperature of 256°. It is to be noted that the amounts of steam going to each of the two closed heaters are substantially the same. Each of these two closed heaters are really small surface condensers, in which condensate is used as circulating water. It is to be noted that, with full load on the turbine, the operating condition which will exist the bulk of the time, one of these closed heaters will operate at a pressure somewhat above atmospheric pressure and the other heater will operate at a pressure somewhat below atmospheric pressure. The steam which is condensed in the high pressure heater will be trapped back into the low pressure heater, where a portion of it will flash into steam, but will be recondensed by the condensate passing through the low pressure heater. The combined drips from the high pressure and low pressure heaters will be trapped back into the hot well of the condenser after having passed

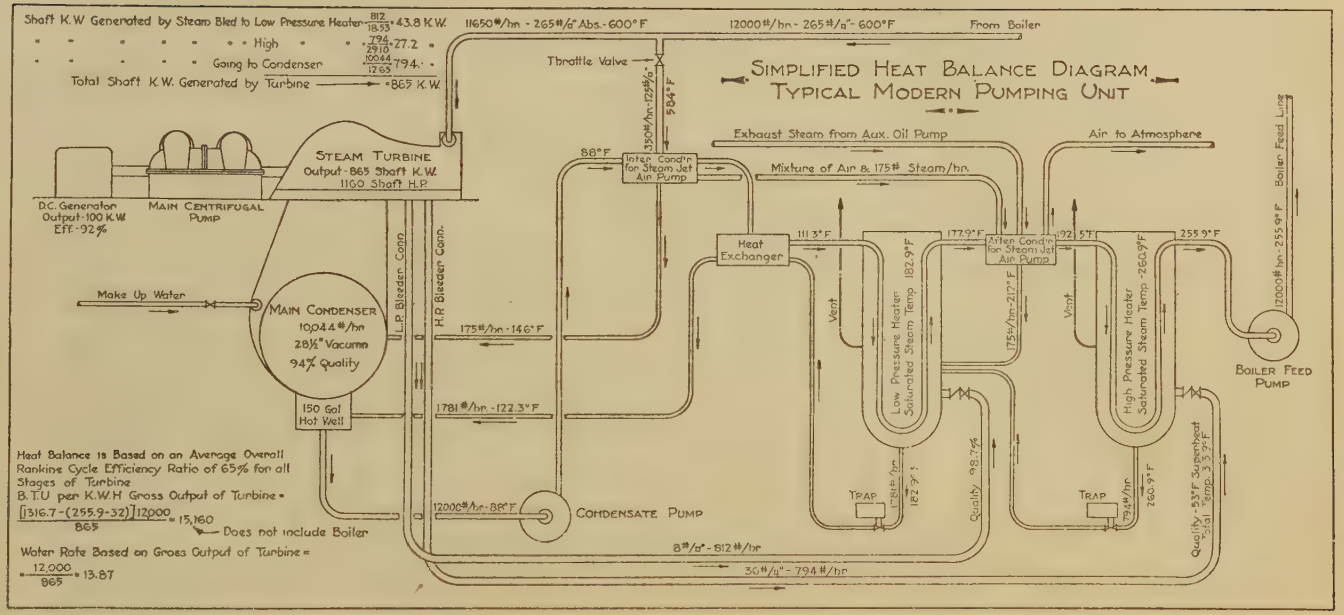
Shaft K.W Generated by Steam Bled to Low Pressure Heater 812/18.53 = 43.8 K.W.
" " " " " " High " " 794/29.10 = 27.2 "
" " " " " " Going to Condenser 10044/12.65 = 794 "
Total Shaft K.W. Generated by Turbine = 865 K.W.
11650#/hr - 265#/6" Abs. - 600° F
12000#/hr - 265#/a" - 600° F
From Boiler
Throttle Valve
SIMPLIFIED HEAT BALANCE DIAGRAM
TYPICAL MODERN PUMPING UNIT
350#/hr - 125#/6"
584° F
Exhaust Steam from Aux. Oil Pump
Air to Atmosphere
88° F
Inter. Condtn for Steam Jet Air Pump
Mixture of Air & 175# Steam/hr.
STEAM TURBINE
Output - 865 Shaft K.W.
1160 Shaft H.P.
D.C. Generator
Output - 100 K.W.
Eff. - 92%
MAIN CENTRIFUGAL PUMP
Heat Exchanger
111.3° F
177.9° F
After Condtn for Steam Jet Air Pump
192.5° F
255.9° F
Boiler Feed Line
12000#/hr - 255.9° F
Make Up Water
MAIN CONDENSER
10044 #/hr
28½" Vacuum
94% Quality
L.P. Bleeder Conn.
H.P. Bleeder Conn.
175#/hr - 146° F
Vent
Low Pressure Heater Saturated Steam Temp. 182.9° F
175#/hr - 212° F
Vent
High Pressure Heater Saturated Steam Temp. - 260.9° F
BOILER FEED PUMP
150 Gal Hot Well
1781 #/hr - 122.3° F
Heat Balance is Based on an Average Overall Rankine Cycle Efficiency Ratio of 65% for all Stages of Turbine
B.T.U per K.W.H Gross Output of Turbine = [1316.7 - (255.9 - 32)] 12000/865 = 15,160
Does not include Boiler
Water Rate Based on Gross Output of Turbine = 12,000/865 = 13.87
12000#/hr - 88° F
CONDENSATE PUMP
TRAP
Quality 98.7%
TRAP
Quality - 53° F Superheat Total Temp. 313.9° F
8#/6" - 812 #/hr
30#/4" - 794 #/hr

FIG. 2

through a heat exchanger in which they will give up the bulk of their heat to the condensate on its way to the low pressure heater. Obviously, with the layout shown here, the greatest amount of available energy in each pound of steam will be abstracted and converted into useful work at the turbine coupling, for we are passing all of the steam through the main turbine which has a very much higher Rankine Cycle efficiency ratio than smaller steam turbines, which in an alternative layout might be used for driving the auxiliaries.

Another factor which is to be borne in mind is this: The cost per horse power of capacity in the turbine which drives the main pump is appreciably lower than is the cost per horse power in connection with small turbines which in an alternative layout would be used for driving the auxiliaries. The increase in the cost of the pumping unit incident to the use of a direct current generator mounted directly on the end of the pump shaft, and the use of the larger turbine which would be required to drive this generator in addition to the pump, will not be great. If we compare this layout for a moment with one in which we use water turbines to drive our auxiliaries, it is to be noted that we are decreasing the total capacity of the pumping station by the use of the water turbines driving the auxiliaries. The capacity of the pumping station is expressed in millions of gallons pumped daily. If we use an appreciable percentage of the water which is handled by the main pump in connection with the water turbines, we are decreasing the net capacity of the pumping station by just that much. I am of the opinion that, if all factors are taken into account, alternative designs laid down on the basis of electric drive for the auxiliaries along the lines which I have indicated, and water turbine drive for auxiliaries, and the total first cost of the station is placed on the basis of first cost per million gallons of water handled daily, the net capacity being taken, the layout with the electric driven auxiliaries will indicate the lower first cost.

I would make one exception to my general recommendation for the use of electrically driven auxiliaries, and that is in connection with the pumps which withdraw the air from the surface condenser. Efficient steam jet air removal pumps are available for this service. These steam jet air removal pumps are reliable, compact, require a minimum of attention, and are low in first cost. When all these factors are taken into account, it is questionable whether we can afford to install anything else than steam jet air removal pumps in connection with the main surface condensers.

It is to be noted that all of these recommendations which I have made make it possible to use a reasonably high steam pressure and temperature. If the steam piping is limited to the main leads between the boiler and the turbines driving the main pumps, the bulk of the small steam piping is eliminated, the number of valves is very much decreased, and it should be possible and economical in connection with the new pumping station to use a steam pressure as high as 250 pounds per square inch and a total steam temperature of 600°F. I would hesitate to recommend going higher than this in connection with the relatively small turbines which will be used in the majority of pumping stations.

I have made suggestions here which are in line with the trend in connection with design of modern steam electric generating stations. I am sure that, if these suggestions are embodied in the design of a pumping station, it will result in a real improvement in the over-all economy of the station without any sacrifice in its reliability. It is to be pointed out, however, that the over-all economy of the steam driven units of approximately 1000 h.p. capacity in a steam driven pumping station can never equal the over-all economy which is obtained in connection with a large steam electric generating station where single units of from 20,000 to 50,000 k.w. are installed. In many cases a careful engineering analysis will, I am sure, indicate that, even if the best possible design is laid down for the steam driven pumping station, the fixed charges and the operating costs of such a station will be higher than the fixed charges, the operating labor and the cost of purchased power in connection with an electrically driven pumping station taking its power from a large efficient steam electric generating station.

VERN E. ALDEN.[3]

HYDROGEN-ION TESTS

The following simple procedure which has been found very satisfactory at Mt. Prospect Laboratory of the Department of Water Supply, New York City, should prove serviceable to smaller laboratories which cannot afford elaborate equipment. Procure from the Pyro-Electric Instrument Company, Chemical Division, Trenton, N. J., "Sterile Universal Buffer Solution M/10 concentration," also

[3] Assistant to General Superintendent, Consolidated Gas, Electric Light and Power Co., Baltimore, Md.

N/5 hydrochloric acid and N/5 sodium hydroxide, sterile and standardized by them. Follow their chart in making standards, 20 cc. volume, making them pH 0.2 apart. Procure brom thymol blue, powdered dye, from any of the firms supplying it for pH determinations. The preparation of the dye solution is as follows, according to Clark: Rub up a decigram of the dye in 3.2 cc. of N/20 sodium hydroxide. Dilute to 25 cc. with distilled water, making 0.4 per cent solution. Dilute again for use to 0.04 per cent solution. Add 1 cc. of the last to 20 cc. volume in making up the standards and solutions to be tested. Instead of using test tubes and a comparison block, it has been found convenient and apparently as accurate and less strain on the eye to make up these standards and solutions to be tested in sterile 2 ounce glass stoppered bottles, such as are used for the regular bacteriological samples. (These bottles are blown seamless and may be procured from Whitall-Tatum Co., New York City.)

The standards have been found to keep remarkably well. The original set made up by us two and a half years ago was recently replaced by a new set and the old standards were found not to have appreciably changed, indicating that the standards were well buffered, had kept well in the sterile bottles, that the glass of these is of excellent quality, and, a very important consideration, that the sterilized solutions furnished by the Company had likewise kept without appreciable change. These standards are checked by the firm electrolytically. We had no means of testing the accuracy in this respect and dependence must be placed upon the firm, but the stability of the standards made from these solutions is an important consideration. In testing bacteriological media add to 1 cc. of warm distilled water 4 cc. of melted agar to which has been added 1 cc. of the dye in one of the above bottles. In another bottle make another portion of diluted media without the dye. In another bottle put 20 cc. of distilled water. In comparing with the standards arrange the bottles on a shelf at the height of the eye with a backing of diffused daylight. Place the distilled water behind the bottle of diluted media containing dye and the bottle of diluted media without dye behind the dye standards. Make up the media (plain agar) as near pH 7.0 as possible. Results will be sufficiently accurate.

FRANK E. HALE.[4]

[4]Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y.

RECARBONIZATION OF SOFTENED WATER[5]

This paper should arouse the interest of water works men whose duty it is to operate water softening plants. Should Mr. Hill's paper do no more than focus attention upon certain operating conditions it will have served a useful purpose.

One of the most perplexing problems in water treatment of this kind is the effect of retarded chemical reactions, resulting in after-precipitation of lime and magnesium salts. Recarbonization may serve as an expedient, but, to the writer's mind, should not be considered entirely satisfactory. To evaluate properly this method, it is necessary to consider its ultimate effect from an economical and practical viewpoint. As has been shown by Mr. Hill, 90 per cent of the chemical reactions at the municipal plant at Columbus, Ohio takes place in the mixing chambers, whereas the remaining 10 per cent requires fifteen hours for removal of the hardening constituents, 7 per cent of which are precipitated in the filter beds and in the piping system. It is evident that, when conditions are favorable, precipitation of lime and magnesium is retarded and when these conditions are changed the softening action is accelerated greatly and the salts are deposited. As a result of retardation of reaction the lime and magnesium, (much of which are in a colloidal or semi-colloidal state) are re-dissolved by the CO_2 added for recarbonization and are passed through the softening system. This will relieve, in a large measure, the operators' difficulty, but puts the burden upon the ultimate consumer, especially when the water is used for steam making, in laundries and in other industrial processes. It may be argued that recarbonization results in only slight increases in the hardness of the water, but even slight increases of incrusting salts involve comparatively large losses to the industries using such water. Every grain per gallon of increased hardness represents a proportional financial loss in steam boiler operation and in soap and soda used in laundries. In addition to this fact there is a proportional reduced efficiency in zeolite softening plant operation and an increased operating charge in maintaining such systems. Similar operating difficulties will prevail in many other types of industrial water purification apparatuses.

[5] See Journal, March, 1924, page 393.

Water purification methods are changing rapidly and many hypotheses conceived a few years ago have been exploded when considered in the light of the present knowledge of physical chemistry. The writer is unwilling to concede that the problem of retarded action in a softening system and after-precipitation is an insurmountable one, nor does it appear unreasonable to assume that the formation of incrustation on sand grains may not be eliminated completely. The solution of this problem lies, the writer believes, not in recarbonization, but in a better understanding of the basic principles of coagulation and dispersion of particles. The statement "that large settling basins are not necessary for the proper chemical re-actions at least, as has always been supposed, and certainly they are not always effective in sedimenting the lime carbonate when it is in a colloidal state" is interesting. This statement may shock many advocates of large subsidence basins. Past experience of the writer has demonstrated the fact that large basins are unnecessary, not only as an adjunct to water softening systems, but also when used in connection with ordinary mechanical filtration. There has been in the past a great waste of funds in the construction of large subsidence basins, the use of which has been a detriment rather than an advantage to efficient plant control.

S. T. Powell.[6]

[6]Consulting Chemist, Baltimore, Md.

SOCIETY AFFAIRS

CALIFORNIA SECTION

The fourth annual convention of the California Section was held at the American Legion Hall, Fresno, California, as the guests of the Fresno City Water Company, October 25, 26 and 27, 1923.

One hundred and forty-three members and guests registered from all parts of the State.

The following papers were read:

Water System of Fresno City Water Corporation, by E. K. Barnum, Engineer of Fresno City Water Corporation.

Proper Arrangement of Plumbing for Buildings Higher than Can be Adequately Served Directly from Distributing System, by George Read, Superintendent, Meter & Service Department, Bureau of Water Works & Supply, Los Angeles. Read by George Pracy of Spring Valley Water Company.

Types of Pipe for Water Main Construction, by S. B. Morris, Chief Engineer, Pasadena Water Department.

Public Relations, by Al. C. Joy, Publicity Manager, San Joaquin Light & Power Corp.

Use of Balancing Reservoirs in Water Distributing Systems, by J. E. Phillips, Assistant Engineer, Bureau of Water Works and Supply, Los Angeles, California.

Effect of Distributing System Design upon Fire Insurance Rates, by Louis Stocklmeir, Engineer, Pacific Board of Fire Underwriters.

Softening of Public Water Supplies, by Gale S. Strout, Consulting Engineer, San Francisco. Read by E. A. Flanders, Associate.

Water Measuring Devices, by R. L. Daugherty, Professor of Mechanical Engineering and Hydraulics, California Institute of Technology, Pasadena.

Reasonable Water Sanitation Requirements, by Dr. Carl Wilson, Bacteriologist, Bureau of Water Works & Supply, Los Angeles, California.

European Experiences, by Chas. Gilman Hyde, Professor of Sanitary Engineering, University of California.

In addition to the above papers the following five minute talks were presented and discussed:

Legal Phase of Installation of Check Valves on Water Services, by C. B. Jackson, Superintendent, Fresno City Water Corporation.

Methods of Financing Water Main Extensions, by P. Diederich, Superintendent, Public Service Department, Glendale.

Water Service Installations Standards, by George A. Bragg, Maintenance Engineer, Pacific Gas and Electric Corporation, San Francisco.

Use of Detector Instruments for Water Works Purposes, by L. L. Farrell, East Bay Water Company, Oakland.

Advisability of Installing Sealed Services Ahead of New Paving, by A. P. Lovell, Superintendent of Water, San Diego.

Roofs for Distributing Reservoirs, by Chas. W. Given, Superintendent of Water Works, Monrovia.

On Friday noon the members were guests of the exhibitors at a luncheon given at the Fresno Country Club. On Thursday night and Friday night the Fresno City Water Company acted as hosts at dinners given to members and guests at the Fresno Hotel, and on Saturday everyone enjoyed an interesting trip to the Kerckhoff Dam and power house of the San Joaquin Light and Power Corporation with lunch at the power house as guests of the Corporation.

At a business meeting held at the Fresno Hotel Thursday evening, October 25, the following officers were elected for the coming year:

Chairman, Fred J. Klaus, Assistant Chief Engineer, East Bay Water Company, Oakland, California; Vice-Chairman, George W. Pracy, Superintendent, Fresno City Water Corporation; Secretary-Treasurer, S. B. Morris, Chief Engineer, Pasadena Water Department.

Additional members of Executive Committee elected are: C. B. Jackson, Superintendent, Fresno City Water Corporation; P. Diederich, Superintendent Public Service Department, Glendale, California.

NORTH CAROLINA SECTION

The annual meeting of the North Carolina Section began Tuesday afternoon, November 13, at which time registration took place.

On Tuesday evening there was a dinner given by the Kiwanis and Rotary Clubs with Judge Guion as Toastmaster. The address of welcome was given by City Attorney Romulus A. Nunn; response by E. B. Bain of Raleigh, President of the North Carolina Section.

There was an address by Congressman Abernethy in which he said that North Carolina needs advertising. It is blessed with natural resources more than other places which have wider fame and prosperity. He also gave an account of his 17,000 mile trip around United States, Alaska, Canada, etc.

Wednesday morning, November 14. The minutes of the Gastonia meeting were read and adopted. The Secretary-Treasurer's report was adopted. Mr. Maffitt's resolution to extend to the Clubs a rising vote of thanks for the dinner and entertainment of the previous evening was unanimously carried. Mr. Kellogg and Mr. Maffitt were appointed as a canvassing committee to canvass election returns.

A letter was read from the Charlotte Chamber of Commerce inviting the Section to hold its next meeting there. Mr. Vest, Superintendent of the Charlotte Water Works, pointed out the opportunities offered by Charlotte and the Southern Power Company at next convention. Mr. Widenhouse invited the Section to meet at Albemarle next year. Telegrams from civic organizations at Albemarle had not been received so Mr. Boyles made a motion to defer the choice of convention city until Thursday morning. This was unanimously carried.

Reports of committees: Statistics Committee, J. C. Michie, Chairman, no report; By-Laws Committee, H. E. Miller, Chairman, no report; Canvassing Committee, Mr. Maffitt made the following report: For President, J. C. Michie; Vice-President, W. M. Piatt; Secretary-Treasurer, T. Saville.

Mr. Godfroy extended an invitation to the members of the convention to make use of the Elks Club rooms. A similar invitation came from the Country Club.

A request was read from the Secretary asking that copies of all papers delivered be submitted to the Secretary.

J. O. Craig gave a paper on Metering Services. In the discussion of this paper Mr. Maffitt said that he was constitutionally opposed to unmetered services; that half of each meter is owned by the city and the other half by property owner in Wilmington. In Wilmington the Board of Health requires water installations metered or vacation of premises. Mr. Bain said that the legality of compulsory payment for meters is to be tested in Raleigh. Mr. Logan of Waynesville said that some towns charge rent on meters.

Mr. Bain introduced Mr. Diven, Secretary of the American Water Works Association, who talked on the growth of membership. Mr.

Diven said that there seems to be a surety of the formation of a Southeastern Section.

M'Kean Maffitt of Wilmington gave a paper on Cross Connections Between Public and Private Water Supplies. Mr. Maffitt made a resolution to the effect that "There shall be no physical connection between the public water supply system and any private water supply system wherein it is possible to get contaminated water into the public water supply system." Mr. McConnell in discussing this paper said that one cross connection can undo all that the best purification plant has done; that it is illogical to exercise extreme vigilance in plant and let industrial or fire supply pollute the system. Mr. Norcom said that the cross connection was an insidious thing, unknown by consumers; if they knew they would rebel against it. Mr. Maffitt said that the New Hanover Board of Health recently prohibited cross connections. Mr. Diven said that a resolution similar to Mr. Maffitt's had been passed by the National Convention; that the matter could be handled by a Board of Health, by statute or force. It usually requires force. Careless tapping of polluted supply in New England mill, where there were two independent supplies, caused an epidemic. Mr. Miller said that the State Board of Health must have the power of public opinion, therefore, the resolution is of great assistance.

H. E. Miller then gave a paper on the Objective, Policy and Procedure of the State Board of Health in Relation to Water Supply.

At noon there was a barbecue at Grantham Farm with extemporaneous talks by various individuals.

On *Wednesday afternoon, November 14,* a meeting was called to order at 2:15. Mr. Godfroy gave a paper on the Water Supply at the New Bern Fire.

J. W. Kellogg of the State Board of Health presented a paper on Algae and their Relation to Water Supplies.

A paper on the Trouble at Albemarle with Tannic Acid Derived from Vegetation and Stumps was presented by Mr. Widenhouse.

A. O. True gave a paper on the Trouble at Proximity with Brownish Gelatinous Substance which Reduced Filter Runs to Three-fourths Hour. Mr. Sweeney of Wilmington stated there had been trouble with air bound filters. The intake was surrounded with logs. Every time the logs were moved, gelatinous material would enter suction lines and form on filter beds, clogging them. This looked like mother of vinegar, skimmed off material. The underdrainage system is

cleaned every three years. The masses of mucilaginous matter came from accumulations on logs at the saw mill.

S. Brockwell spoke on Fire Protection. This paper was discussed by Mr. Maffitt, who gave his experience with a know-all fire chief at Wilmington. A 12-inch main was needed for fire supply, the fire chief wanted a 6-inch main. They compromised on a 10-inch and an 8-inch. The first fire got away from him. There should be coöperation between water and fire departments.

The members of Section convened on Wednesday evening for a supper, where Mr. Diven spoke on the benefits from membership in the Association.

There was a stirring talk by Mr. Bain urging North Carolina to win the Membership Cup and give it back to the National Association in the spirit in which it was donated. Mr. Maffitt and Mr. Craig talked on the advantages of being a member of the A. W. W. A.

Col. Ludlow talked on the importance and responsibility of providing domestic water supply; the safety and health of urban population are in the hands of the superintendent of water works; every water works man should appreciate the opportunity of becoming a member of the A. W. W. A.

Mr. Godfroy urged rotating the convention each year from east to west. He said he desired the record of the largest one-year increase in membership.

Gilbert C. White made a motion to give Mr. Godfroy and the ladies of New Bern a rising vote of thanks for entertainment. This was unanimously carried.

Mr. Brockwell contributed fun, jokes and songs.

Following this Mr. Wright gave a paper on the Hendersonville Water Supply, illustrated with lantern slides.

There was a discussion by Gilbert C. White emphasizing the popular demand for an unfiltered gravity system. He said that municipalities are often willing to pay 20 per cent of the total cost for this.

The question of laying pipe up steep slopes was discussed by Mr. Maffitt. Mr. Wright answered this by saying he used double bells at each blown-off; pipe should be laid from valleys *up* slopes of hills.

Mr. Norcom gave a study of the efficiency of the improved water purification plant at Wilmington. Mr. Catlett discussed the improvement of water plants in the State. Mr. Craig discussed the reduction in cost from using coal at $5.50 a ton and electricity at

1.72 cents k.w. hr. Mr. P. B. Streander of the Roberts Fibre Company said that within the last two years North Carolina had done more than any other three states in the construction of filter plants.

Mr. C. C. Covert gave a paper on Stream Flow Records for Water Supply, illustrated with lantern slides.

Mr. W. E. Hall, District Engineer, United States Geological Survey, discussed the importance of stream flow records on small as well as large streams, and the importance of getting long records for future water supply studies. He said that it is just as important to get stream flow records for sewerage. Accurate sewage flow records by this method should be had to determine treatment plant required.

Mr. Gilbert C. White asked about cost of gaging stations. The following data were given by Messrs. Hall and Covert: cost of installation of automatic gaging stations averages about $400 to $500; cost of instrument $140; cost of maintenance and installation about $200 per year; cost of sender and recorder for long distance recording station $375 approximately. In his discussion Mr. Covert advocated good permanent installations.

Mr. Maffitt gave Charlotte's experience with investing $276,000 in pipe line in 1904, and the stream going dry in 1911. Mr. D. McWilliams said that the minimum discharge must be known; with different conditions in the state there is no definite run-off per acre. Mr. Hall said that in Asheville there had been an inadequate supply of water because of no gaging and no meters on the line. Mr. Williams had advocated both. The city was almost out of water because of no impounding. This could not be foreseen because of inadequate records. They were short of water in 1922. Mr. Maffitt, in discussing the matter, said that when stage at Fayetteville is 2 feet 4 inches salt water got to Wilmington; this could be foreseen if there were adequate gaging stations. Mr. Brockwell's discussion was to the effect that the subject is so large that it extends beyond municipalities, and is a problem of such scope as to demand statewide attention. He recommended that the Section go on record to memorialize the General Assembly to provide funds to make thorough and complete stream flow studies. Mr. Brockwell made a motion that committees be appointed to urge the General Assembly to provide sufficient funds to make a "thorough survey of the State." This motion was seconded by Mr. Gilbert C. White. Mr. Brockwell suggested that no amount of money is too much to provide these

data. He wants North Carolina to take an active part in this work. Mr. D. McWilliams discussed the advantage of including gaging stations as part of other improvements at water plants. Mr. Brockwell's motion was unanimously carried.

Thursday morning, November 15. Unfinished business was first taken up. Mr. Widenhouse withdrew the invitation to hold the next convention at Albemarle, and moved that Mr. Vest's invitation to have the next convention at Charlotte be accepted. Mr. Maffitt boosted Wilmington for 1925. Mr. W. E. Hall boosted Asheville for 1925, and Mr. D. McWilliams also boosted Asheville for 1925. Charlotte's invitation was accepted.

Mr. W. J. Alexander offered an amendment to the motion of the previous day, "that State Board of Health notify all parties having cross connections that the same be removed or disconnected from the city water supply within a reasonable length of time." Mr. Maffitt in his discussion said that the State Board of Health does not say "must"—Need more force behind local water works officials whose hands are tied. Mr. Hall suggested that the resolution would be backing for the State Board of Health and he seconded the amendment. The motion was unanimously carried. Mr. H. E. Miller said that it is necessary for the State Board of Health to be backed by public sentiment; if the matter goes to court this resolution will be the strongest evidence in favor. Mr. Boyles favored the appointment of a committee to work out a plan for furnishing water to fire supply to avoid cross connections and made a motion to appoint this committee.

Mr. E. G. McConnell of Charlotte gave a paper on the Accurate Control of an Old Filter Plant. Mr. Vest in discussing this paper said that $5000 a year was a conservative estimate of the saving made by trained operators. Mr. Diven said that there are laws in two states requiring the examination of filter plant operators.

Mr. Miller gave the report of the Resolution Committee. Mr. Miller made a motion for the adoption of this report. Mr. Maffitt seconded the motion and it was unanimously carried.

Mr. E. E. Peacock of the University of North Carolina gave a paper on Cost Accounting System for Water Works Systems of Large Towns and Small Cities. In his discussion of this paper Mr. Maffitt brought out the importance of a standardized accounting system. Mr. Norcom said it is necesary to have a standardized accounting system if we are able to compare operating costs of different purifi-

cation plants of the State. It is difficult for anyone to determine costs accurately in accounting systems used at present and to arrive at the depreciation.

Mr. H. F. Davis of Wallace and Tiernan Company gave a paper on the Use and Handling of Chlorinators.

At *noon Thursday* there was an oyster roast at the New Bern Power Plant.

Mr. S. G. Lantz of the Darling Valve and Manufacturing Company gave the first paper at the *Thursday afternoon meeting.*

Mr. True gave a paper on the Disposal of Wastes from Dyehouses and Textile Plants. Mr. True's paper was discussed by Mr. Maffitt.

Question box: Mr. Diven will send questionnaire regarding standardization of services. Mr. Miller spoke of the importance of Mr. Peacock's paper; also of Statistics Committee, its work and significance; should stimulate better methods of accounting and record keeping; requires coöperation of water works operators and superintendents.

The President appointed the following Committee on Stream Flow: S. Brockwell, Chairman; M'Kean Maffitt and D. McWilliams.

The Acting Secretary reported the registration for convention as being 130 and 26 new paid memberships. The convention adjourned *sine die.*

NEW YORK SECTION

On January 17 the New York Section, through its Secretary, invited the Sanitary Division of the American Society of Civil Enginners to join with them in a luncheon meeting at the Hotel Pennsylvania. This invitation was accepted by them and an enthusiastic and enjoyable meeting ensued. This meeting was addressed by Mr. Geo. W. Fuller, on double filtration of water supplies in Europe.

In the absence of the President, Chas. R. Bettes, of the New York Section, Mr. D. W. French, one of the Board of Governors, presided and Mr. Kenneth Allen, Chairman of the Sanitary Division of the American Society of Civil Engineers spoke a few words for them.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health. 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The 8 m.g.d. Sioux Falls Iron Removal Plant. F. G. GORDON. Eng. News-Record, 91: 882–3, 1923. Water supply is obtained from large shallow wells. It is pumped to aerators of weir-step type, settled, and filtered. 16 filter units, each with capacity of 500,000 g.p.d. when operating at rate of 125 m.g.d. per acre. Plant cost $11,125 per m.g. capacity. Raw water contains 4 to 5 p.p.m. Fe, which is reduced to 0.15 p.p.m.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Tile Drains Collect Water for Small City Supply. R. E. KOON. Eng. News-Record, 91: 854–5, 1923. Condon, Ore., with a population of 1300, is located 2900 feet above sea level with no available water supply at this elevation. 6 in. tile lines with open joints, placed 6 to 12 feet below stream bed, give filtered supply which is chlorinated before use. Supply is pumped 4 miles and elevated 723 feet to town.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Industrial Waste Pollution Conference a Success. ANON. Eng. News-Record, 91: 682–4, 1923. Conference held in Philadelphia, under joint auspices of Engineers' Club and local section of Amer. Soc. C. E., October 16, 1923. Topics discussed: federal and state control of pollution; stream pollution as affecting navigation; industrial wastes in relation to water supply; stream pollution at Philadelphia; and coal mine drainage contamination of water supplies.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Concrete Bottom for Mechanical Water Filters. A. L. GAMMAGE. Eng. News-Record, 91: 430–1, 1923. Filter bottom is all of concrete, including channels, raised half cylinders with horizontal under-slots to form jets, and 3 in. spheres placed in spaces between tops of the half cylinders. Slots are ½ inch horizontal, 20 inches apart lengthwise. Ratio of slot discharge varies from 0.3 to 0.5 per cent of filter area. With this ratio, filters have filtered and washed evenly, leaving a level sand bed even when sand was dirty. This type of bottom replaced metal strainer and air-wash system at East Walpole, Mass. —*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Deferrizing Additional Water Supply of Berlin, Germany. GORDON M. FAIR. Eng. News-Record, 91: 426–9, 1923. Supply taken from wells, 115 to 200 feet deep. Average daily yield from each well, 78,000 gallons. Water

contains 8 p.p.m. Fe, which is entirely removed by aeration followed by filtration through gravel beds and sand filters.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Local Laboratory Control of Water Supplies in California. C. G. Gillespie. Eng. News-Record, 91: 401, 1923. State Board of Health is advocating installation of laboratories to make simple bacteriological tests on water supplies. These tests give valuable data in case of litigation and damage suits; apprise officials and consumers daily of safety of supply; and stimulate interest of operator in character of water treated. A list of recommended equipment is given.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Pollution of Water Supplies by Coal Mine Drainage. C. P. Collins. Eng. News-Record, 91: 638–41, 1923. Oxidation of pyrites causes acid character of coal mine waters. About 1 pound CaO, per 1000 gallons waste water, is required to neutralize acid and precipitate Fe. This treatment is recommended, with two hours sedimentation. Collins suggests thorough study of mine drainage treatment by United States Bureau of Mines.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Pitometer Survey Discloses Underground Leaks. G. H. Fenkell. Eng. News-Record, 91: 432–3, 1923. Pitometer survey, from 1919 to 1922, resulted in eliminating underground leaks amounting to 9,557,000 gallons daily; 3,380,000 gallons daily, unmetered fixature leakage, and 9,600,000 gallons daily, metered fixature leakage, were also eliminated; representing total of 24 gallons per capita per day saved. Per capita consumption for 1922 was 184 gallons. Detroit supplies 954,000 people and is 98.5 per cent metered.—*Frank Bachmann.*

Disinfecting the City Water Mains of Otsego, Michigan. E. D. Rich. Eng. News-Record, 91: 431–2, 1923. Population of Otsego in 1920 was 3168. The polluted Kalamazoo river has been used for water supply, but not for drinking, for eight years. Recently, a deep well supply was put in service. Water mains were disinfected by dosing the 130,000 gallon suction well with 9 p.p.m. Cl for twenty-four hours. Dead ends were flushed until free Cl was detected. After Cl treatment discontinued, flushing was kept up until Cl reactions negative.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Final Report on Franklin Furnace Typhoid Outbreak. C. K. Blanchard. Eng. News-Record, 91: 429, 1923. An open gate valve and a leaky check valve between industrial and town supply systems of the N. J. Zinc Co. was probable cause of 114 cases of typhoid and 8 deaths. The specific infection was traced to 2 cases of typhoid, dejecta from which probably reached the Walkill river. —*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Controller Regulates Water Flow through Pressure Filters. C. C. Brown. Eng. News-Record, 91: 446, 1923. Automatic control of flow is accomplished by closing or opening of butterfly valve, by movement of rod attached to rubber diaphragm in middle of chamber, 2 parts of which are connected by pipes to trailing and leading sides of orifice in filter effluent pipeline.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Making Meter Maintenance Pay Big Dividends in Texas. J. W. Hockaday. Eng. News-Record, **91**: 439, 1923. When meters were neglected at Cleburne, Tex. income fell off; but, with meter maintenance, revenue increased $1.75 for every dollar expended on maintenance, and operating expenses decreased $5. Cf. this Journal, **10**: 823, 1143.—*Frank Bachmann.*

Elimination of Cat-Tails from Reservoirs. L. E. Bishop and C. R. Knowles. Eng. News-Record, **91**: 509, 1923. Cat-tails exist under swampy conditions. Lowering ground water level below creeping root stalks will kill the plants. Another method suggested is to pull plants out by hand destroying roots as far as possible. Use of creosote oil, applied at water's edge, is also effective.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Water-Works Dam Withstands Record Flood. V. V. Long. Eng. News-Record, **91**: 724–6, 1923. Oklahoma City dam passed almost 5 times designed capacity, though 250 feet of the corewall failed. On October 15, peak flow doubled June record flow in North Canadian River. While damage was great, there was no interruption of service. *Frank Bachmann.*

Pennsylvania Sanitary Water Board: Powers, Duties, and Policies. W. L. Stevenson. Eng. News-Record, **91**: 684–5, 1923. Board consists of secretaries of health, forests, and waters, attorney general, commissioner of fisheries, and chairman of public service commission. Functions are: to administer laws of state prohibiting pollution of its waters; and to study, investigate, and report on, ways of eliminating and preventing stream pollution detrimental to public health, animals, fish, or aquatic life, or to recreational uses. Streams are divided into classes. Class A are pure streams into which no contaminating wastes are permitted. In class B, pollution is controlled. Sewage and industrial wastes may be discharged into class C streams provided no public nuisance or menace to health is created.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

How Shall We Gage Water-Supply Purity? Edit. Eng. News-Record, **91**: 624–5, 1923. Urges caution in methods employed by United States Public Health Service to control standard of purity of water supplies. In promoting public health in water supplies, Service may be retarding progress along other lines which may bring greater returns for same expenditures. Judging character of supply by standard based on bacterial examination alone, may force a city to expend large sums of money to comply with this arbitrary standard, with no evidence that lives will be saved, or sickness prevented, thereby. Much weight should be given to sanitary survey and to vital statistics of a community, in deciding whether or not its water supply is safe for use on interstate trains and steamers.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Iron Removal and Softening Plant, Benton Harbor, Mich. Pearse, Greeley and Hansen. Eng. News-Record, **91**: 378–9, 1923. Water is taken from deep wells and the St. Joseph River. Because of an Fe content of 2 p.p.m. and hardness of 250 p.p.m., CaO is added to reduce both constituents. Plant has

nominal capacity of 2 m.g.d.: consists of: mixing chambers; Dorr clarifier, with 1 hour detention; sedimentation basins, with 8 hours detention; sand filters; and storage reservoir. Clarifier removes bulk of precipitate continuously, thereby reducing the number of times sedimentation basins must be emptied and cleaned. Clarifier provides means for returning portion of settled sludge to raw water so as to promote rapid reaction and precipitation of CaO with HCO_3^- in water. Expts. on aeration with 4⅔ hours sedimentation indicated no effect on Fe removal. Sand filtration removed Fe; but accumulations of Fe and crenothrix growth in filter were objectionable. CaO treatment gave best results with filtration, reducing Fe from 2 p.p.m. in raw H_2O to 0.1 p.p.m. in the filtered H_2O.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

The Corrosion of Yeovil (England) Water Mains in Clay. C. H. Webb. Water and Water Eng., **25**: 294, 1907, June 20, 1923. On 8 inch main laid in 1872 there were 14 bursts in clay section in 1922. The part of line laid in sand was in good condition. Holes occurred in vicinity of bells, on lower part of the pipe, where it lay in wet clay. Decomposition of pipe took two forms: (1) Graphite softening in absence of scale; (2) Similar softening, beneath scale formation. In case (1), metal is pitted; in case (2), it may be cut out with a knife, though soft areas recover their hardness on exposure. Yellow and gray clays affected pipe more than boulder and blue clays. $CaSO_4$ is present in crystals and ground water is high in SO_4. It is suggested that variation in concentration of ground water may produce electrical effect. Coating of bells was evidently abraded in handling, which was probably not considered important fifty years ago. Recoating is advised.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Drinking Water of the Côte d'Amour (La Baule and Le Pouliguen). "L. D." L'Eau, **16**: 8, 85, August 15, 1923. La Baule, resort town near St. Nazaire, France, aerates and filters iron-bearing dune water. Aeration is accomplished by cascades. Settled water is applied to non-submerged sand filters by revolving sprinklers. Loire river sand is used. Plant was built in 1912.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

On the Use of Metallic Pipes. E. Fijalkowski. L'Eau, **16**: 8, 89, August 15, 1923. Polemical against author of paper attacking use of cast iron pipe in gypsum-bearing earth, on strength of experiences in Tunis. F. opposes use of steel pipe in moist earth even when tarred and covered with jute. Experiences cited are chiefly Italian.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Regulation of Wash Houses (Lavoirs). Marchoux. Rev. hyg., **45**: 8, 735, August, 1923. Dangers to the water supplies taken from streams below wash houses are detailed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Sydney Water Supply. Anon. Water and Water Eng., **25**: 296, 296, August 20, 1923. Two reservoirs, on Cordeaux and on Avon, are under construction and will increase storage of Nepean water shed from 20,743 to 84,553 million Imp. gallons. Another reservoir at Lupton, on Nepean river, will

add 11,600 million Imp. gallons.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Effect of Free Chlorine on the Gudgeon. ANON. L'Eau, 16: 7, 81, July 15, 1923. Wastes from a sewer were observed apparently to kill trout. Inquiry on waste (rinse waters from dye works), showed 3.5 p.p.m. free Cl. No trout being available, experiments were tried with gudgeon, and it was found that these fish, of about 10 cm. length, died in about two and one-half hours in water containing this quantity of free Cl. It was shown that sodium bisulphite could be used to destroy free Cl. Court of Appeals at Nancy held that wastes could easily be rendered harmless and assessed small fine against directors of dye works.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Experiments on the Contamination of "Petit Cidre" and the Transmission of Diseases of the Typhoid Type. P. PAQUET. Rev. hyg., 45: 8, 749, August, 1923. Recent epidemic traced to "petit cidre" (Rev. hyg., 45: 165, 1923.) "Petit cidre" is prepared by covering with water residue from pressing apples, afterwards pressing mass a second time. Pond water is much preferred for this maceration as it is soft; minerals in well waters affect subsequent fermentation. Pond water may be polluted. Quick consumption seem to be necessary in order to transmit typhoid; as typhoid, para A, and B organisms have only ephemeral existence in fermented product. B. coli is more resistant.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Estimation of Iodides in Mineral Waters Containing Sulphides. J. DUBIEF. Ann. des falsifications, 172–3, 80–2, 1923, Water and Water Eng., 25: 296, 304, August 20, 1923. When water containing sulphides, sulphites, and organic matter, is treated with $KMnO_4$, first in alkaline, then in acid soln., immediate oxidation takes place; Cl, Br, and I are liberated. I can be estd. by adding given amts., of $NaHCO_3$, CS_2, H_2SO_4; with H_2O_2 to destroy excess $KMnO_4$. Test lies in comparing color of unknown and samples containing known amounts of KI.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Three Reports on Question of the Divining Rod. ANON. Water en Gas, May 11, 1923; Water and Water Eng., 25: 296, 305, August 20, 1923. Subject is taken very seriously in Germany. Difficult to get operators to appear before juries of observers.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Estimation of Free Chlorine in Drinking Water. W. OLSZEWSKI. Water and Water Eng., 25: 296, 291, August 20, 1923. Iodide of starch is sensitive to 0.21 p.p.m. free Cl: sensitiveness may be increased to 0.1 p.p.m. by filling flask from the bottom and agitating with 2 grams KI and 5 cc. of fresh 1 per cent starch soln. Orthotolidine gives good results, but Mn and Fe interfere, giving bluish green color. Olszewski prefers Raschig's benzidine soln. in HCl, as used for SO_4 detns. Waters high in SO_4 give precipitate. Carbonates cause trouble. Determine alkalinity in usual way; add enough 0.5 N HCl to neutralize; and enough Raschig's soln. to give 0.016 to 0.02 grams benzidine per liter.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sterilization of Water with Liquid Chlorine and Deodorization by Aeration, Anon. Técnica, 55–71, May 1923; Water and Water Eng., **25**: 296, 306, August 20, 1923. Apparatus used is made by Patterson in England, Wallace and Tiernan in United States, and "Triton" in Germany. Pressure gages are similar, but volumetric meters differ widely, esp. in United States and English types. Particulars and diagrams of process of combining use of chlorination with pressure aeration.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Anaerobes from Water Samples. P. D. Meader and E. A. Bliss. Amer. Jour. Hyg., **3**: 4, 394, July, 1923. Expts. were made with 76 tubes of lactose broth cultures which had yielded gas, but failed to confirm as B. coli. Tubes had been inoculated with raw and treated waters in State Board of Health Laboratory, in Maryland. Sixteen, or 21 per cent of tubes, contained anaerobes, but only two of anaerobes recovered fermented lactose with production of gas; from which it is concluded that number of anaerobes which give false presumptive tests for B. coli is not as great as generally supposed. Presence of anaerobes seemed to bear no relation to total bacterial count in water samples.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Practical Application of the Oligodynamic Action of Copper Salts on Bacteria. Arch. Hyg., **89**: 253–61, 1921. From Chem. Abst. **16**: 1968, June 20, 1922. Disinfectant action of copper foil, referred to as oligodynamic action of copper, was investigated. One hundred thousand bacteria were apparently killed in 24 hours by concentration of 1 p.p.m. copper chloride; but, on removal of copper with ammonium sulfide, bacteria were still viable. Disinfectant action was inhibited by organic matter in concentrations which occur in natural waters.—*R. E. Thompson.*

Cataphoresis of Colloidal Carbon. Stephanie Goldberg. Kolloid-Z., **30**: 230–4, 1922. From Chem. Abst., **16**: 2052, July 10, 1922. On addition of aluminum sulfate, velocity of migration to anode passed through a maximum of 33×10^{-5} cm./sec./volt at N/500,000.—*R. E. Thompson.*

Electroadsorption as a Purely Chemical Phenomenon. Wo. Ostwald. Kolloid-Z., **30**: 254–60, 1922. From Chem. Abst. **16**: 2053, July 10, 1922. Development of adsorption formula on basis of law of mass action can yield practical results only when, in place of stoichiometric mass of adsorbent, there is substituted active mass, which consists of sum of chemically active surface layers.—*R. E. Thompson.*

The Theory of the Migration Velocity of Particles in a Viscous Medium when acted on by an External Force. H. F. Mayer. Jahrb. Radioakt. Electronik. **18**: 201–39, 1921. From Chem. Abst. **16**: 2053, July 10, 1922.—*R. E. Thompson.*

Adhesion Forces in Solution. II. Studies on Adhesion Series. N. Schilow, Z. physik. Chem., **100**: 425–62, 1922; cf. C. A. **14**: 1775. From Chem. Abst. **16**: 2055, July 10, 1922.—*R. E. Thompson.*

Dissociation and Hydrolytic Equilibria in Solutions of Salts of Carbonic and Boric Acids. H. Menzel. Z. physik. Chem., **100**: 276–315, 1922. From Chem. Abst., **16**: 2056, July 10, 1922. Mean value obtained by colorimetric and electrometric methods for second dissociation constant (K_2) of carbonic acid at 18° was 6.2×10^{-11} From this value, 1.03×10^{-4} is obtained for second hydrolytic constant.—*R. E. Thompson.*

The Slow Hydrolysis of Salts. A. Tian. J. chim. phys., **19**: 190–216, 1921. From Chem. Abst., **16**: 2058, July 10, 1922. Discussion and theory of hydrolytic equilibria which are slowly established.—*R. E. Thompson.*

Chemical Reactions and Radii of Curvature. R. Luce. Compt. rend., **172**: 1287–8, 1921; cf. C. A. **15**: 2375. From Chem. Abst. **16**: 2058, July 10, 1922. Further experiments in support of view that chemical action of liquid on solid depends on shape of latter, being greatest where mean curvature is greatest. Thus influence of curvature is same in liquids and gases.—*R. E. Thompson.*

The Molecular Scattering of Light in Water and the Color of the Sea. C. V. Raman. Proc. Roy. Soc. (London), **101A**: 64–80, 1922; cf. C. A. **16**: 529. From Chem. Abst. **16**: 2076, July 10, 1922. Sufficiently deep layers of water exhibit, by molecular scattering, a deep blue color which is primarily due to refraction. Intensity of molecular scattering is approximately 160 times that of dust-free air.—*R. E. Thompson.*

How Life and Performance of the Lead Storage Battery May be Extended by Proper Care. M. F. Packard. Coal Age, **21**: 733–4, 1922. From Chem. Abst., **16**: 2082, July 10, 1922. Surface should be protected by acid-resisting paint, and corrosion of terminals retarded by use of grease. Specific gravity of electrolyte should be 1.27–1.28 at 21° with a correction of 0.001 for each 1.7° above or below this temperature.—*R. E. Thompson.*

The Use of Colored Glass in Place of Liquids in Colorimetric Investigations. Klas Sondén. Arkiv. Kimi, Mineral., Geol., **8**: No. 7, 10 pp., 1921. From Chem. Abst. **16**: 2090, July, 10, 1922. Preparation and use of colored glass in H-ion concentration determinations, nesslerization, etc.—*R. E. Thompson.*

A Starch Indicator Solution. W. J. Painter. Analyst, **47**: 166–7, 1922. From Chem. Abst., **16**: 2090, July 10, 1922. Boil common household rice starch and equal weight of sodium carbonate with usual quantity of water. Cool and add concentrated hydrochloric acid until acid to litmus. Add a little zinc, allow to stand twenty-four hours, and filter the neutral solution. Will keep 8 months.—*R. E. Thompson.*

Influence of Ethyl Alcohol on the Color Change of Phenolphthalein. R. Wegscheider. Z. physik. Chem., **100**: 532–6, 1922. From Chem. Abst., **16**: 2090, July 10, 1922. At transition point in alcohol solution H-ion concentration is 9×10^{-12} and the OH-ion concentration 2×10^{-4}.—*R. E. Thompson.*

Xylenol Blue and its Proposed Use as a New and Improved Indicator in Chemical and Biochemical Work. Abraham Cohen. Biochem. J., **16**: 31–4, 1922. From Chem. Abst., **16**: 2090–1, July 10, 1922.—*R. E. Thompson.*

Colorimetric Estimation of Phosphoric Acid. Ach. Grégoire. Bull. soc. chim. Belg., **29**: 253–8, 1920. From Chem. Abst., **16**: 2093, July 10, 1923.—*R. E. Thompson.*

The Determination of Free Acid in Aluminum Sulfate Solutions. H. Zschokke and L. Hauselmann. Chem.-Ztg., **46**: 302, 1922. From Chem. Abst., **16**: 2093, July 10, 1922. To 10 cc. alum solution add 10 cc. 10 per cent barium chloride, 5 cc. 10 per cent potassium ferrocyanide (not over 6 days old), and 60 cc. boiling water. While shaking, add warm 2 per cent gelatin solution (may be preserved with nitrobenzene) until precipitate is flocculent and settles well (about 1 to 1.5 cc.). Dilute to 100 cc., filter, and titrate 50 cc. of filtrate with $N/10$ sodium hydroxide, using methyl orange as indicator.—*R. E. Thompson.*

The Application of the Indicator Method to the Examination of Stomach and Intestinal Juice. L. Michaelis and F. Mueller. Deut. med. Wochensch., **48**: 252, 1922. From Chem. Abst., **16**: 2154, July 10 1922. Colorimetric method with nitro and dinitrophenols and crystal violet.—*R. E. Thompson.*

The Analysis of Water. F. Touplain. Chimie et industrie, **7**: 634–9, 1922. From Chem. Abst. **16**: 2189, July 10, 1922. Scheme of analysis recommended for identification of samples of unknown origin comprises determinations of conductivity, freezing point, refractive index, ionization, residue at 180°, sulfated residue, chlorine, bromine, iodine, arsenic, and sulfur (in its various forms). Portable apparatus for conductivity determinations is described.—*R. E. Thompson.*

Substances Dissolved in Rain and Snow. Sherman Shaffer. Chem. News, **124**: 35–6, 1922. From Chem. Abst., **16**: 2190, July 10, 1922. Details of analyses of 45 samples collected at Mount Vernon, Iowa, given. No regular differences in amounts dissolved by rain and snow observed.—*R. E. Thompson.*

Hypochlorous Acid and Chlorine, with Comparisons of Bleaching Action. R. L. Taylor. Am. Dyestuff Rep., **10**: 329–30, 347–9, 1922. From Chem. Abst., **16**: 2200, July 10, 1922. Bleaching with chlorine may not be altogether due to decomposition of water, as chlorine may act directly on coloring matter.—*R. E. Thompson.*

Cement and Its Painting. Anon. Farben-Ztg., **27**: 1652–3, 1922. From Chem. Abst., **16**: 2207, July 10, 1922. New cement should be allowed to age before painting. Methods of treatment where this is impossible are given.—*R. E. Thompson.*

Boiler Room Performance and Practice of the Colfax Station, Duquesne Light Co. C. W. E. Clarke. Mech. Eng., 44: 295–300, 1922. From Chem. Abst., 16: 2212, July 10, 1922. Fuel and fuel handling equipment, stokers and clinker grinders, ash handling and sampling, piping and feed water systems, and boiler plant of 7 B. and W. boilers described. Average efficiency for six months, 77.5 per cent.—*R. E. Thompson.*

Bleaching with Hypochlorite. Rasser. Chem. Tech. Ind., 19: 457–9, May 10, 1921. Chimie et industrie, 7: 764, 1922. From Chem. Abst., 16: 2229, July 10, 1922. Sodium hypochlorite, particularly electrolytic, most important hypochlorite. Sterilization of linen was complete, even with resistant pathogenic organisms, in four hours with 2 per cent available chlorine. Cost compares favorably with bleaching powder.—*R. E. Thompson.*

Standard Scouring Systems. J. Schofield. J. Soc. Dyers and Colour., 37: 298–301, 1922; cf. C. A. 15: 760. From Chem. Abst., 16: 2228, July 10, 1922. Water containing 6 to 7° hardness should be softened for scouring purposes. Surface water should be filtered.—*R. E. Thompson.*

The Minimum Solubility of Aluminium Hydroxide in Water. A. Massink. Chem. Weekblad, 19: 66, 1922. From Chem. Abst., 16: 2246, July 20, 1922. To explain differences in results of Am. investigators (A. Wolman and F. Hannan and also Blum) and those of Ada Prins and of Van de Sande Bakhuyzen, it is pointed out that former did not use chemically pure water, while latter took this into consideration.—*R. E. Thompson.*

Hour Radioactivity of Mineral Waters. Carbonic-Sulfur-Boric Waters of the Saturnia Hot Springs. R. Nasini and C. Porlezza. Giorn. chim. ind. applicata, 3: 543–5, 1921. From Chem. Abst., 16: 2256, July 20, 1922.—*R. E. Thompson.*

Report of Water-Softening and Purification Works for the Year, 1921. Chas. P. Hoover. City Bull. (Columbus, Ohio) 7: 16, 12–21, 1922; cf. C. A. 15: 3352. From Chem. Abst., 16: 2377, July 20, 1922. 7936 million gallons softened (lime soda) to average hardness of 100 p.p.m. Average reduction in bacteria from 2450 to 24 per cubic centimeter, 10 deaths from typhoid occurred during year.—*R. E. Thompson.*

The Purification of Turbid Water for Use in Boilers. Anon. Wärme u. Kälte Technik. 24: 81, 1922. From Chem. Abst., 16: 2377. Brief description of purification by precipitation, settling and filtration.—*R. E. Thompson.*

Whitewashes and Aqueous Lime Paints. G. L. Fink. J. Ind. Eng. Chem., 14: 503–11, 1922. From Chem. Abst., 16: 2418, July 20, 1922. Those containing siccatives are much more permanent. Casein and linseed oil are best binders. Addition of hardening agents, such as formaldehyde, to render film less soluble, considerably improve durability. Sodium chloride and alum added to whitewashes containing no definite siccative improve workability and permanence.—*R. E. Thompson.*

Water Softening for Industrial and other Purposes. J. P. O'Callaghan. J. Soc. Dyers and Colourists, **38**: 81–4, 1922. From Chem. Abst., **16**: 2189, July 10, 1922. Comparison of Lassen-Hjort and permutit methods.—*R. E. Thompson.*

Condition Equation of Water. O. Tumlirz. Sitz. Akad. Wiss., Wien. Abt. IIa, **130**: 93–133, 1921. From Chem. Abst., **16**: 2444, August 10, 1922. Equation of state for water developed and verified by experiment. Occurrence of maximum density depends solely upon manner in which cohesion pressure depends on temperature.—*R. E. Thompson.*

Demonstration of the Use of a Universal Indicator. F. H. Carr. Analyst **47**: 196–7, 1922. From Chem. Abst., **16**: 2458, August 10, 1922. Range and color changes of universal indicator of Moir, modified by Cocking and Chappel, for water testing. Changes correspond to spectrum. pH range, 3 to 11.—*R. E. Thompson.*

Purification of Water and De-incrustation of Boilers. F. H. Lecomte. E. P. 200, 466, 1.8.22. Conv., 5.7.22. Jour. Soc. Chem. Ind., **42**: 46, 1094A, November 16, 1923. Boiler compounds are prepared by mixing with water a small proportion of ultramarine, alum, and naphthalene, and a large proportion of sodium carbonate. A suitable compound is prepared by mixing 100 liters of water at 17°C. with 2 grams of ultramarine blue until a uniform coloring is obtained; 5 grams of naphthalene and about 12 grams of alum are then added whilst constantly stirring, followed by the gradual addition of 160 kilograms of sodium carbonate. The paste obtained is allowed to rest for about 7 mins. and then poured into moulds, or upon plates, to cool and solidify. One kilogram of this composition is used with 20 cb.m. of water to remove scale, and one-third the quantity to prevent its formation. Material may be used to purify water for laundry purposes and for treatment of sea water (W. T. L.).—*A. M. Buswell.*

Manufacture of Base-exchanging Compounds. J. Crosfield and Sons, Ltd., T. P. Hilditch, and H. J. Wheaton. E. P. 203, 158, 14.8.22 and 1.5.23. 1094A. Jour. Soc. Chem. Ind., **42**: 46, 1094A, November 16, 1923. Homogeneous gels, which when washed and dried may be used as base-exchanging compounds (cf. E. P. 177, 746; J., 1922, 372 A.), are obtained by mixing solutions of sodium silicate in which ratio of silica to alkali is not less than 3.3 to 1, with solutions of one or more of the following—sodium chloride, sodium chlorate, sodium sulphate, sodium nitrate, disodium phosphate. With a silicate having a ratio of silica to soda between 3.3:1 and 3.7:1 a concentrated solution of silicate is required (sp. gr. 1.2–1.4) and also a concentrated solution (50 per cent) of the other sodium salt or salts employed. With silicates of ratios 3.7 of silica and upwards, to 1 of soda, less concentrated solutions give good results (W. T. L.).—*A. M. Buswell.*

Process of Regenerating Base-exchanging Compounds after Use. J. Crosfield and Sons, Ltd., T. P. Hilditch, and H. J. Wheaton. E. P. 203, 497,

14.8.22. Jour. Soc. Chem. Ind., 42: 46, 1094A, November 16, 1923. In the regeneration of base-exchanging compounds in accordance with E. P. 4188 of 1913 (J., 1914, 216), the greater part of the lime and magnesia is removed by first portions of the brine. Economy is effected by preliminary treatment with solution, or solutions, partially spent in previous regenerations. For final treatment, fresh unused brine is employed, which, after use, is reserved for subsequent operations (W. T. L.).—*A. M. Buswell.*

Process for Purifying Water. P. Herrero. E. P. 203, 886, 1.9.22. Jour. Soc. Chem. Ind., 42: 46, 1094A, November 16, 1923. Process for purification of water by means of barium bicarbonate in solution and calcium hydroxide (cf. E. P. 20, 591 of 1908; J., 1909, 324). Water, kept in continual agitation by means of stream of air mixed with purified carbon dioxide, when saturated with carbon dioxide, is treated with finely ground barium carbonate, in small quantities at a time, until sulphates present are completely precipitated. At this stage, passage of carbon dioxide is discontinued, and milk of lime added, to remove the bicarbonates of calcium, magnesium, etc., formed, together with the small amount of barium bicarbonate remaining in solution. When reaction is complete, agitation is stopped and mixture allowed to settle (W. T. L.). —*A. M. Buswell.*

Occurrence of Iodine in Nature. T. von Fellenberg. Mitt Lebensmittelunter. Hyg., 14: 161–240. Chem. Zentr., 94, III, 986, 1923. Jour. Soc. Chem. Ind., 42: 45, 1068A, November 9, 1923. Gives simple qualitative test for iodine, sensitive to 0.4 mg. per kg. With this test, author determined the iodine in air, soil, fog, surface and ground waters, and a large number of fruits, vegetables, and other food materials. He confirms Chatin's conclusion, that cretinism can be brought about by lack of iodine and can be prevented by administration of sufficient iodine. (Cf. J., 1923, 945A.)—*A. M. Buswell.*

Chemistry of Surface Waters and Filtration Processes. Hurdelbrink. Gas. u. Wasserfach, 66: 570–72, 1923. Jour. Soc. Chem. Ind., 42: 50, 1195A, December 14, 1923. Brown incrustation in pipes of water supply of town of Königsberg from time to time becomes detached, and causes discoloration of the water. Examination showed such low proportion of organic carbon that crust could not have been formed by action of humic acid on iron. It was essentially ferric oxide and also contained 1.8 per cent elementary sulfur. Its periodical formation and removal was therefore probably due to variations in amounts of carbon dioxide and oxygen in solution, disappearance of latter also favouring growth of sulfur bacteria. Regular tests were made of fluctuations of content of oxygen, carbon dioxide, iron, and organic matter, at different periods of the year, before and after filtration. It was shown that reduction of oxygen content and of content of oxidisable organic matter, and increase of carbon dioxide content, are permanent effects of filtration. Very marked effect was shown by periods of frost in winter during which filters were frozen over and aeration prevented. Other seasonal changes were ascribed to development of bacterial life in the water in proportion as temperature favoured this (C. I.).—*A. M. Buswell.*

Rapid Method for the Purification of Drinking Water. C. A. Grau. Anal. Asoc. Quim. Argentina, 11: 82–85, 1923. Jour. Soc. Chem. Ind., 42: 50, 1195A, December 14, 1923. Following solutions are recommended for rendering doubtful waters potable: Solution A; iodine, 8 grams; potassium iodide, 2 grams; glycerin 2 cc.; ethyl alcohol, 90 cc. Solution B; sodium thiosulfate 15 grams; glycerin, 5 cc.; water, 45 cc.; ethyl alcohol, 40 cc. Five drops of Solution A are added to each litre of water. If water is not thereby colored slightly yellow, a few more drops are added. After agitating occasionally for 20 minutes, an equal volume of Solution B is added. Products of reaction between Solutions A and B, 0.03 grams of sodium tetrathionate and 0.008 grams of sodium iodide per litre, are considered to be harmless (G. W. R.).—*A. M. Buswell.*

Apparatus for the Separation of Gases from Liquids. H. Wade. From W. S. Elliott. E. P. 204, 363, 29.5.22. Jour. Soc. Chem. Ind., 42: 50, 1196A, December 14, 1923. An apparatus for removing gases from liquids such as boiler-feed water, which depends for its effects on sudden ebullition of preheated and finely divided water in vacuum, is constructed as far as possible with all apparatus in or on one vessel, which forms the vacuum chamber, so as to avoid friction and heat losses in pipework.—*A. M. Buswell.*

Ammoniacal Liquor for Softening Water. Chevalet. Soc. Tech. de l'Ind. du Gaz en France. Gas J., 163: 735, 1923. Jour. Soc. Chem. Ind., 42: 42, 996A, October 19, 1923. Boiler-feed water is preheated and softened in apparatus comprising 5 superposed trays, each 40 cm. in diam., capacity of plant being 500 liters per hour. Ammoniacal liquor is added at rate of 50 liters per twenty-four hours, and water is agitated with steam as it flows over each tray. When temperature of 60°C. attained, the ammonium carbonates primarily formed are decomposed, the ammonia passing upwards with steam, and softening more water. Water thus treated passes into settling tank of 4 cub. m. capacity (H. Hg.).—*A. M. Buswell.*

Determination of the Content of Active Carbon Dioxide in Drinking Waters. P. Lehmann and A. Reuss. Z. Unters. Nahr. Genussm., 45: 227–236, 1923. Jour. Soc. Chem. Ind., 42: 42, 996A, October 19, 1923. A consideration of the work of Schloesing (Comptes rend., 74: 1552, 75: 70, 1872) and application of law of mass action lead to deduction of following formula for calculating combined carbon dioxide, c, in drinking water from total carbon dioxide, t, both expressed in mg. per litre:—

$$c = (\sqrt[3]{t + t^2 + 5823} + \sqrt[3]{t - t^2 + 5823})\ 27$$

If t exceeds 200, a correction is necessary on account of carbonate not being completely dissociated at higher concentrations. This correction factor is deduced to be $2772.9/(2886-c)$. Table is given of sums of concentrations of combined and active carbon dioxide corresponding to experimentally determined total carbon dioxide concentrations, calculated by means of above formula, correction factor being applied where necessary. Details are given of methods of determining combined and free carbon dioxide by titration with hydrochloric acid using methyl orange as indicator, and with sodium

carbonate using phenolphthalein as indicator, respectively. Active carbon dioxide in water containing calcium sulfate must be determined directly by experiments on powdered marble, according to Van Heyer's method (Gesundheitsing. 35: 675, 1912; see also Kolthoff, J. S.C.I., 1921, 95A). (H. C. R.).—*A. M. Buswell.*

Detection of Nitrites (in Water) by Rodillon's Test. H. Heller. Chem. Zeit., 47: 701, 1923. Jour. Soc. Chem. Ind., 42: 42, 996 A, October 19, 1923. Leffmann's failure (J. S. C. I., 1923, 326A.) to obtain consistent results by use of Rodillon's test (J. S. C. I., 1923, 27A) is due to heating acid used in dissolving the resorcinol. Good results are obtained by shaking 0.4 gram resorcinol with 5 cc. cold concentrated sulphuric acid, and introducing 1 cc. of this solution below 5 cc. of water to be tested, contained in test-tube. A green to violet or blue color at interface denotes presence of nitrites. (Cf. J. C. S., October.) (A. R. P.).—*A. M. Buswell.*

Apparatus for Removing Gases from Boiler Feed Water and Other Liquids. The Griscom-Russell Co., Assees. of R. C. Jones. E. P. 196, 238, 5.7.22. Conv., 14.4.22. Jour. Soc. Chem. Ind., 42: 42, 996A, October, 1923. Feed water is sprayed into chamber under reduced pressure in which it is heated by tubular heat exchanger. In order to loosen, or crack, scale deposited on tubes, these are so formed that they are flexed or deformed upon subjection to changes of temperature. For this purpose, each tube may be slightly bowed out of a straight line, or its cross-section may be deformed out of a true circle. In latter case, flattened sides of adjacent tubes, or of adjacent turns of spiral, or helical, tube, are preferably disposed adjacent to each other (H.H.).—*A. M. Buswell.*

Water Supply and Purification. George W. Fuller. Am. Pub. H. Assn., 1923. Can. Engr., 45: 487-8, 1923. General review of water supply, water supply projects, excess Cl, effect of mine drainage, corrosion of service pipes, and modification of U. S. P. H. S. standard.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Method and Cost of Constructing Malone Diversion Dam. Reclamation Record, Sept. 1923. Eng. Contrg., 50: 1048–9, 1923. Construction of earth dam, with concrete spillway, and canal headwork, is described in detail with cost data.—*Langdon Pearse.*

Water Works Accounting System of Charleston, S. C. E. E. Evans. Tri State Water & Light Assn., 1923. Eng. Contrg., 50: 1050–1, 1923. Details are given of meter system, and books; with recommendations for sinking fund, depreciation charges, and proper accounting on extensions.—*Langdon Pearse.*

Repairing Coagulation Basins with Cement Gun. A. S. Holway. Eng. Contrg., 50: 1004–6, 1923. To repair concrete disintegrated by frost, cement gun was used with forms having one side and top. Work was done on cost plus basis, costing $42.90 per cubic yard in place.—*Langdon Pearse.*

Operation Records for Small Water Works. E. L. Waterman. Am. W. W. Assn. (Iowa), 1923. Eng. Contrg., 50: 1007–8, 1923. Better records are urged for small works.—*Langdon Pearse.*

Shrink-fitting Heavy Shaft Assembly. C. V. Foulds. Eng. Contrg., 50: 1009–10, 1923. To assemble generators on shaft, spider hubs were heated by steam, then placed and cooled.—*Langdon Pearse.*

Problems of the Private Water Company. W. W. College. Eng. Contrg., 50: 1038–40, 1923. General discussion of rate making and accounting, with reference to Pennsylvania conditions.—*Langdon Pearse.*

Supervision of Water Treatment Plants in Michigan. E. D. Rich. Am. W. W. Assn. (Iowa), 1923. Eng. Contrg., 50: 1041–2, 1923. Details methods of supervision used. Local laboratories are encouraged.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Roof Truss Derrick Erects Standpipe. Eng. Contrg., 50: 1042–3, 1923. In erecting standpipe, 60 feet in diameter by 100 feet high, the roof trusses were used to form derrick.—*Langdon Pearse.*

Financing Water Main Extension by City Owned Plants. H. F. Blomquist. Am. W. W. Assn. (Iowa), 1923. Eng. Contrg., 50: 1045–6, 1923. Methods of financing by special assessments, or contract, are described, with reference to Iowa conditions.—*Langdon Pearse.*

The New Pumping Unit of Trenton, N. J., Water Works. Eng. Contrg., 50: 1047–8, 1923. Roots pump, driven by 850 H. P. Uniflow engine; delivery, 20 m.g.d., against 155 feet head.—*Langdon Pearse.*

Water Works Addition in New England. Allen Hazen. N. E. W. W. Assn., 1923. Eng. Contrg., 50: 1023–7, 1923. Describes in detail new work underway at New Britain (wells), Springfield (enlarging filter), Providence (new filters), Poughkeepsie and Albany (pre-treatment).—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Adopting Proper Schedule of Water Rates. W. W. Rich. Eng. Contrg., 50: 1032–4. Recommends budget system; eliminating leaks; metering all services; making rates according to cost, based upon service charge plus meter charge.—*Langdon Pearse.*

"Our Water Supplies." Edwin Thompson. Chem. Ind., 42: 48, 1152 R, 30 November, 1923. A brief survey of water supply and purification problems in Great Britain with historical notes concerning the Glasgow, Manchester, London, and Liverpool supplies.—*A. M. Buswell.*

New Suggestion for Earth Dam. F. A. Noetzli. Am. Soc. C. E., Can. Engr., 45: 555, 1923. Urges consideration of use of water tight diaphragm,

built up of two layers of granite, on slope of 1½:1, with asphalt between.—*Langdon Pearse.*

Blind Slough Dam at Stave Lake, B. C. A. F. Tredcroft. Can. Engr., **45**: 541–4, 1923. Describes concrete dam 640 feet long, equipped with 10 stop log bays, each 22 feet long, and 4 Taintor Gates, each 19 feet ½ inch wide. Foundations are on granite. Methods of construction and plant are described. —*Langdon Pearse.*

Concrete Underdrains at Worcester. H. P. Eddy. Pub. Works, **54**: 379–80, 1923. In the sand beds handling sewage containing spent pickling liquids from wire mills, etc., concrete underdrains have disentegrated; possibly because of (1) peat underlying the beds, (2) acid in the sewage, (3) putrefactive condition in overloaded filters.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Self Purification of Rivers. W. H. Frost, Am. Pub. Health Assn., 1923, Pub. Works, **54**: 386, 1923.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Derrick as Dragline. F. C. Sellnon. Pub. Works, **54**: 387, 1923. In building the Wanaque dam, a stiff leg derrick is used as dragline, and also as cableway.—*Langdon Pearse.*

Pollution of Kansas River. Kansas State Board of Health, Pub. Works, **54**: 399, 1923. Self-purification leaves river in fair condition above Topeka. Below Topeka, conditions vary.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Purification Statistics. Pub. Works, **54**: 399–401, 1923. Data are tabulated from 70 cities. Ninety-three per cent use Cl; 56 per cent filter.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Memphis New Waterworks. F. G. Cunningham. Am. Soc. Mun. Improvements, 1923. Pub. Works, **54**: 371–4, 1923. Will serve about 165,000 population, now using 13 mil. gal. per twenty-four hours. New system of wells and new pumping plant replace the old. Aeration and filtration reduce high CO_2 (90 to 130 p.p.m.) and Fe (0.2 to 6.0 p.p.m.). Average daily supply of 18 mil. gal. is provided, at cost of $2,800,000. Air lifts will raise water into a receiving basin. Special precautions are taken for sightliness, and for care in making maintenance repairs.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

The Need of Covering Open Service Reservoirs. George C. Bunker and August C. Nolte. Amer. City, **30**: 15, 1924. (Abstract from paper before N. E. Water Works Assn.) Sound arguments are presented for the covered reservoir. Advantages of making cover part of original installation are pointed out.—*W. Donaldson.*

City of 10,000 Builds $50,000 Water System. Charles Martel Niles. Amer. City, **30**: 21–23, 1924. Ilion, N. Y., is completing new gravity supply works. An earth fill, concrete-core-wall dam, 726 feet long and 80 feet high.

will provide 150 mg. storage, sufficient for five months supply. Creek supplying reservoir is fed from springs. Impounded water is piped to service reservoir near village where it is aerated through 70 spray nozzles; then passed through sand filter (type not stated) into covered clear basin which supplies distribution system. Chlorination is provided for emergency use. Watershed is being systematically reforested.— *W. Donaldson.*

How Privately Owned Water-Meters May Be Acquired. ANON. Amer. City, 30: 41–42, 1924. Methods outlined and form of contract given.—*W. Donaldson.*

Data on Water Furnished Schools. ANON. Amer. City, 30: 45, 1924. Tabulation of 21 Kansas municipalities show that a charge is customary for water furnished schools; that the charge is not less than made against other consumers; and that no difference in rate is made between board of education office and school buildings.—*W. Donaldson.*

Protection of Wells Against Contamination by Cemeteries. M. LE COUPPEY DE LA FORREST. Rev. D'Hyg., 45: 8, 741, August, 1923. Author recommends, in place of requirements regarding distance intervening between dwellings and cemeteries, the lapse of time occurring before the ground of old cemeteries is again used for inhumations, and similar rules, the matter should be placed in hands of a competent geologist who should prescribe regulations for each locality, depending on character of soil, drainage, etc.—*A. W. Blohm. (Courtesy U. S. P. H. Eng. Abst.)*

Influence on Fish and Other Forms of Stream Life of Washings from Bituminous Roads. Standing Committee on Rivers Pollution (1921). Ministry of Agriculture and Fisheries. Report No. 40. In laboratory test young perch and roach showed no ill effects after three hours with extract from pulverized bituminous road material. In practical test, two-year-old brown trout were unharmed after 19 weeks in pond receiving actual drainage from bituminous road.—*A. W. Blohm.*

Influence of Hydrochloric Acid as a Typical Acid and Sodium Hydroxide (Caustic Soda) as a Typical Alkali on Fish Life. C. H. ROBERTS AND E. C. JEE. Standing Committee on Rivers Pollution (1921). Ministry of Agriculture and Fisheries. Report No. 36. Time until "Loss of Equilibrium" (basis for expressing endurance of fish) in acid of strength 1:5000, was nine minutes for perch and seven minutes for roach. With 1:10000 acid, period was thirteen minutes for perch and sixteen minutes for roach. With 1:5000 sodium hydroxide, the period was thirty-one minutes for perch and thirty minutes for roach. In 1:10,000 sodium hydroxide both endured forty minutes. Conclusion is that comparatively small concentrations of free acid or alkali are harmful to fish life.—*A. W. Blohm.*

The Inception and Development of the Idea of Free Public Baths. JEANIE WENTWORTH WELLS. Jour. Am. Assoc. for Promot. Hyg. and Pub. Baths, 5:

14, 1923. Development from ceremonial bath of ancients to modern public bathing facilities.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Swimming Pool Sanitation. M. Z. Bair. South. Med. Jour., 16: 10, 764, October, 1923. Sanitation and safety important features in design of pool. Filtration, disinfection, care of suits and towels discussed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Technique of Physiological Experiments as Carried out at the Fisheries Experimental Station of the Ministry of Agriculture and Fisheries at Alresford, Hants. C. H. Roberts and E. C. Jee. Report No. 39, May, 1923. It is assumed, from experiments, that if yearling perch or trout suffer no harm during one to three hours treatment in given effluent, such effluent is in all probability not directly harmful to stream life. In an experiment, time and nature of adverse symptom is noted. Symptoms may be: rapid or unusual mode of swimming; distension of gill covers; gulping of jaws; quivering of body; loss of equilibrium.—*A. W. Blohm.*

Influence of Common Salt on Fresh Water Fish. C. H. Roberts. Ministry of Agriculture and Fisheries. Report No. 38, February, 1923. Small perch and roach withstood three-hour exposure to brine containing 575 parts combined chlorine per 100,000, about ⅓ strength of sea-water. Equilibrium was lost in ten minutes on raising strength to 860 parts. Valuable report applicable to places where drainage (saline in nature) is discharged into streams or lakes, killing or driving out fish life.—*A. W. Blohm.*

Some Observations on Aural Conditions Resulting from Pool and Sea Bathing. H. Marshall Taylor. South. Med. Jour., 16: 2, 134, February, 1923. Author records epidemic of acute external ear, middle ear, mastoid, and sinus infections among users of pool at Jacksonville, Florida, in 1917. Proper methods of operation and preventive sanitary precautions caused immediate cessation of epidemic. Lowering of body temperature and consequent lowering of resistance increasing susceptibility to pathogenic organism, is discussed.—*A. W. Blohm.*

The Causes and Prevention of Otologic Conditions Following Swimming and Diving. H. Marshall Taylor. Jour. Am. Med. Assoc., 81: 5, 349, August 4, 1923. Reduction of temperature, or irritating chemicals, by stopping wave like motion of ciliated epithelium lining of nose, etc., and washing away of bactericidal nasal mucus may increase susceptibility to infection. Destructive action of water by osmosis may cause edema and acidosis of cells and eventually cell death. Author suggests plugging of nostrils and ears when bathing, and limitation of bathing period, in addition to present precautions.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

The Mechanical or Rapid Filter—Improved False Bottom Design. Indian and Eastern Engineer, 42: 4, 145, October, 1923. Advantages of Wheeler Filter bottom pointed out to be: (1) Minimum of metal used; (2) metal parts

of simple construction; (3) complete distribution of wash water and high velocity; (4) maintenance of underdrain system in undisturbed condition; (5) wash water delivered at 15 gallons per square foot of filter at comparatively low head on wash water.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

The Effect of Industrial Waste on Water Supply. Jour. Am. Med. Assoc., **81**: 14, 121, October 6, 1923. Certain wastes in water result in tastes, sometimes medicinal and disagreeable, when water is chlorinated. Chlorophenol tastes were obtained when phenol was present 1 part in 750,000,000. Coke wastes should be kept out of the supply.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Double Filtration of Water as Practised in Europe. Fire and Water, **75**: 4, 163, January 23, 1924. Water purification in European cities, especially the practice of double filtration in some cities taking supplies from highly polluted streams, was treated by George W. Fuller, C.E., at the joint meeting of New York Section, A. W. W. A., and Sanitary Section, A. S. C. E., held in New York, January 17.—*A. W. Blohm.*

Report on Investigation of the Pollution of Streams. N. Y. State Conservation Commission, 1923, pp. 50. Second in importance to sanitary sewage is waste from milk plants, which constitute two-thirds of the 3000 manufacturing plants listed as possible contributors to stream pollution in New York State. Use of streams in disposal of waste is important and legitimate and should be permitted and encouraged up to point of interference with use of greater value to community. Certain streams should be adjudged unfit for water supply and their use for such purpose prohibited, while streams properly used as source of supply should be guarded against pollution which would overload purification plants. Dilution is the controlling factor in all classes of wastes. Standards should be expressed in clear and definite terms, readily understandable, and demonstrable by definite tests. Cycle of formation and decomposition of organic matter is outlined, and aërobic and anaërobic decomposition and function of dissolved oxygen in oxidizing and stabilizing organic matter in water are discussed. Tests employed for determining quality of water are listed and their interpretation discussed, particular attention being given to the B. coli test and Wells's interpretation of same. Review of former work on living indicators of stream pollution and on oyster purification, and bibliography of ten references are included. Establishment of a Conservancy Commission, for regulation and control of uses of streams as affecting quality of water, is recommended.—*R. E. Thompson.*

Lateral Earth Pressure: The Accurate Experimental Determination of the Lateral Earth Pressure, Together with a Resumé of Previous Experiments. Jacob Feld. Proc. Amer. Soc. Civ. Engs., 49: 4, 603–60, April, 1923. Tests on a model wall, 6 feet high and 5 feet wide. Tests with sand indicate reliability of Poncelet theory of maximum wedge causing oblique pressure. Settling and variation in temperature cause remarkable changes in lateral

pressure. Platform scales, adjusted to a movement of 0.004 inch, were used. A resumé of previous experiments is given.—*John R. Baylis.*

Theoretical Frequency Curves. H. Alden Foster. Proc. Amer. Soc. Civ. Engs., 49: 5, 825–55, May, 1923. Contains numerous mathematical formulas, and suggests use of frequency curves for computing stream run-off.—*John R. Baylis.*

The Disintegration of Cement in Sea Water. William G. Atwood and A. A. Johnson. Proc. Amer. Soc. Civ. Engs., 49: 6, 1039–64, August, 1923. Brief history of the study of cement for use in sea water. Attempt to make use of a standard cement for all purposes has probably been the cause of many failures. All experiments for the past 100 years agree that primary cause for disintegration in sulfate-bearing waters is the attack on free lime by sulfates. Disintegration may be prevented by adding to cement a properly constituted silicious material which will form a cementing material insoluble in sulfate-bearing waters. High alumina cement attains the same result. Authors conclude that in view of the great volume of previous research work, the study being made at University of Saskatchewan, and the general agreement in results obtained, it is unnecessary to make further tests to determine causes of failure of concrete in sulfate-bearing waters.—*John R. Baylis.*

Some Notes on British Water Works Pumping Engines. F. Johnstone-Taylor. Fire & Water Eng., 74: 399, August 29, 1923. Majority of water works engines built in Britain today are of three cylinder, three crank, triple expansion, rotative direct acting type, general arrangement of which follows closely the Reynolds engine, as favored by American engineers: they are built for highest possible duty. The Worthington non-rotative compensated engine is installed in a fair number of units, and since its original introduction from America, has been well thought of by British engineers; but the rotative type, as outlined, is generally preferred. Where these engines are unsuitable, or too costly, compound engines of horizontal side-by-side type, with plunger pumps operated by the piston tail rods, are used to some extent; the American type, with pumps in front of the steam end, and flywheel in between, is practically unknown in Britain. Centrifugal pumps for high lifts are being appreciated more than formerly, for those plants where electric power is cheap. American practice of steam turbine driven centrifugals has never "caught on" in Britain, but the Diesel engine is coming to the front, especially for bore-hole pumps with vertical shaft driven by gearing. The Metropolitan Water Board (London supply) have also a number of Diesel engine-driven ram pumps of considerable capacity for pumping, in the main, to high level service reservoirs. Illustrations show English built pumping engines in the Palermo pumping station in Buenos Aires and in the Hong Kong water works. The large engines are designed for the most economical operation when combined with a modern boiler plant; a steam consumption of about 11 pounds per pump horse power is generally called for, this being the method whereby most British engineers measure the efficiency, as opposed to foot pounds of work per pound of coal.—*Geo. C. Bunker.*

What Shall It Be, Meters or Additional Supply? NICHOLAS S. HILL. Fire & Water Eng., 73: 1013, May 23, 1923. There are two primary reasons for use of meters. First, that volumetric measurement is the only fair and logical basis on which to sell water, because only thus can gross inequalities and discriminations be avoided. Second, metering is the only way yet found of restricting needless waste. Idea that meter restricts legitimate use of water is erroneous. Water is cheapest of all necessities of life supplied to residents of towns and cities. Meter system has the advantage that it does not restrict consumer in installation of adequate plumbing equipment, as fixture rates do; consumer soon learns that amount of water consumed is not proportional to number of fixtures installed, so long as plumbing is kept from leaking. All that meter does, is to restrict needless waste which occurs on all unmetered systems. If one were to assume that the only reason for installation of meters was saving in capital outlay and operating expenses effected thereby, he would commit a grievous error. As a practical matter, conditions under which water works in the United States have been developed in last 30 years have greatly changed; need of stopping waste, for purpose of conserving available sources of supply, has become more important and is becoming more and more important each year. Another sound argument for introduction of meters is, that only thus can a water department be efficiently operated. The water works manager operating with master meters which register amount of water delivered into distribution system, but with no means of measuring water actually consumed, is very seriously handicapped in determining sources of waste; whereas, if all consumers are metered, he can sum up consumption, as measured by consumers' meters, compare revenue-bearing water consumed with that pumped, and take steps to remedy intermediate losses. No basis exists for a rational system of flat charges. A scale of rates is at best a makeshift. The front-foot charge has the least to recommend it. No correlation can be established between front-footage and consumption of water. Of flat rate methods of charging, the fixture rate is the least illogical; but use of water from fixtures will vary enormously with different consumers. The amount of water for which consumer pays a given sum, with fixture rate, depends upon mere whim. Great evil of all flat rate charges is that they place no premium upon restriction of waste. General principles for proper rate structure are given. Saving effected by installation of meters in East Orange, N. J., is discussed; also the anticipated saving in Baltimore, Md.—*Geo. C. Bunker.*

Let the Citizens Know What the Water Works Really Does. J. E. GIBSON. Fire & Water Eng., 74: 11, July 4, 1923. General information concerning water rates, collections, and periods of meter readings. Thorough discussion of monthly, versus quarterly, readings of meters and issues of bills is included; conclusion reached, that quarterly reading and billing has met requirements of efficient management in Charleston, S. C. Six tables contain useful information.—*Geo. C. Bunker.*

The Square Deal in Water Works Valuation. C. P. LAMBERT. Fire & Water Eng., 74: 61, July 11, 1923. General discussion of equitable method of valuation of privately owned water company.—*Geo. C. Bunker.*

The Proper Way to Figure Hydrant Rentals. A. S. Holway. Fire & Water Eng., 74: 103, July 18, 1923. Brief outline is given of the three general methods of computing cost of fire protection service: the Comparative Method; the Excess Method; the Proportional Method. Determination of an equitable charge for fire protection service in Oklahoma City is cited as example. Cost of such service should be paid by taxation.—*Geo. C. Bunker.*

The Municipal Water Works System Versus the Privately Owned Plant. W. A. Stanfield and J. W. Kelly. Fire & Water Eng., 74: 106, July 18, 1923. Mr. Stanfield argues in favor of municipal ownership, and Mr. Kelly in favor of private ownership.—*Geo. C. Bunker.*

Use of Reinforced Concrete on Small Reservoirs and Tanks. Johnstone-Taylor (England). Fire & Water Eng., 74: 118, July 18, 1923. Mainly to show how tanks may be made watertight without linings. Author is not in favor of applying asphaltic or waterproofing compounds. Experiments carried out in England at National Physical Laboratory showed that even rich concrete was porous under head of 20 feet, but degree of porosity decreased after several weeks, less by supposed silting up of pores than by swelling of concrete. Impermeability does not depend so much upon richness of mix as upon proper proportioning of sand and aggregate. Plastering interior surface with a very rich mixture is unsatisfactory, as the lining invariably breaks away from the concrete. The now recognized procedure is, to cast a rich face on concrete itself. Base concrete may be a 1-2-4 mix, and water face a 1-1-2 mix, 1½ in. thick. Latter is placed first against timber sheeting and a temporary sheet iron plate resting against the reinforcement. Base concrete is immediately rammed in, and iron plate withdrawn, the two sections being then thoroughly puddled together. Illustrated.—*Geo. C. Bunker.*

Example of Well Designed Small City Water System. S. A. Sulentic. Fire & Water Eng., 74: 122, July 18, 1923. Brief description of improvements made to water system. Illus.—*Geo. C. Bunker.*

How Mains Should Be Laid under Railroad Tracks. Emery E. Ferguson. Fire & Water Eng., 74: 153, July 25, 1923. It is standard practice in Charleston, W. Va., to case mains running under railroad tracks, using old wrought iron or steel pipe. Smaller casings, under 4 inches, are driven with hammers and wooden blocks or by pipe driving jacks. Description is given of installation of 10-inch casing for 6-inch main. Illustrated.—*Geo. C. Bunker.*

Unit Cost of Laying Cast Iron Pipe. Fire & Water Eng., 74: 165, July 25, 1923. Table, taken from twenty-first annual report of David A. Heffernan, Sup't. of Water Dep't. of Milton, Mass., shows unit costs of installing fifteen 6-inch and one 12-inch cast-iron mains. Cost per foot varied from $1.91 to $4.15.—*Geo. C. Bunker.*

Why Water Works Men Favor Auto Pumper for Fire Pressure. J. Arthur Jensen. Fire & Water Eng., 74: 199, August 1, 1923. Adequate hose pres-

sures are more economically attained by motor pumpers than by increased pressure in the water system. Fire apparatus is more flexible, mobile, and efficient for fire fighting than with ordinary hydrant pressures. Risk is obviated of applying additional pressure to water mains, services, and plumbing, at critical hours. Statistics indicate that about 80 per cent of water plants do not increase their pressures for fires, and that fire departments do not depend upon water systems for such pressures, but develop their own pressures either by motor pumps, separate high pressure systems, or both. Data are given affording comparison of cost of fire engine pumping with that of increasing the pressure in water system.—*Geo. C. Bunker.*

Taking the Guesswork out of Water Leakage. E. E. Bankson. Fire & Water Eng., 74: 207, August 1, 1923. Examples of leaks located by use of Pitometer and Geophone in Piedmont, W. Va., and in Patton, Pa. Combination of Pitometer with Geophone can produce most surprising results in finding leaks in hands of an experienced man. Illustrated.—*Geo C. Bunker.*

An Excellent Water Company Advertisement. Fire & Water Eng., 74: 261, August 8, 1923. Reproduction of newspaper advertisement of Davenport, Ia. Water Company, showing what average American citizen does with his income. Only 0.21 per cent is spent for water supply.—*Geo. C. Bunker.*

Keeping Tab on Water Consumed by Private and Industrial Users. Fire & Water Eng., 74: 262, August 8, 1923. Letter from Harry Ellsworth, Supt., Water & Light Dept., Meadville, Pa., shows how consumption of water distributed among following classes:—domestic, commercial, industrial, railroads, city, schools, and sprinkling. Data cover the year 1922 by quarters. —*Geo. C. Bunker.*

Cutting Costs with an Automatic Booster Pump. Ormond A. Stone. Fire & Water Eng., 74: 299, August 15, 1923. Description of the main booster pump station of the water works of Hayward, Calif. Water from wells is delivered into 100,000 gallon concrete pumping sump by air lifts. In booster station are two direct connected motor driven centrifugal pumps, with capacity of 500 g.p.m. against head of 305 feet, motors of which are controlled by automatic starting compensators, operated through float switches installed in pumping sump. In installation was included an air chamber so designed as to limit rise in pressure in the line, in case of instantaneous stoppage of pumps, to normal pumping pressure. Plant has been in successful operation for two years, and, with exception of periodic oiling, has required no attendance. Pumping costs were reduced 3⅓ cents per 1000 gallons by the new equipment, or approximately 30 per cent. Illustrated.—*Geo. C. Bunker.*

Keeping Down the Operating Cost of Standby Pumping Units. E. M. Proctor. Fire & Water Eng., 74: 345, August 22, 1923. For the small water works plant pumping below 4 million gallons per day, the gasoline engine driven centrifugal pump has become standard equipment. Gasoline engines are built to operate at speeds between 1000 and 1400 r.p.m. If equipped with

storage battery electrical starting equipment, they can be started almost immediately and have proved very satisfactory. Fuel consumption is usually about 1 pint of gasoline per hour; although sometimes not much over ½ pint. A pump supplying 1000 gallons per minute at 100 pounds pressure will cost $2.71 per hour, or 4.5 cents per 1000 gallons, with gasoline costing $0.31 per imperial gallon. This is a high cost of pumping, but when one takes into consideration the capital costs of the various units as well as the comparatively short time which this pump will be operated, the operating costs of the gasoline driven pump are, without doubt, the least. A centrifugal pump of 4 million gallons per day capacity, against 230 feet head, connected to a G. R. C.-8 Sterling engine, costs about $7,000.00, f.o.b. factory, or figuring pump and engine together, cost per horsepower is about $25.00. For standby unit in a larger plant it is doubtful if one could improve upon semi-diesel oil driven engine, direct connected to a generator, to supply power in an emergency for motors of pumps. Cost per horse-power for semi-diesel oil engine is about $100.00. Illustrated.—*Geo. C. Bunker.*

Some Practical Results of 100 Per Cent Metering. A. E. Walden. Fire & Water Eng., 74: 349, August 22, 1923. Advantages of meterage over flat rate system are brought out forcibly and pertinently. Proof of waste under flat rate system is easily obtained by examining statistics of cities where change from flat rate to metered rate has been made. Reduction in pumpage of 40 to 50 per cent is usual. Under flat rate system, cost of effective operation, inspections, pitometer tests, waste surveys, etc., will more than offset cost of meters. Unlike flat rate inspections, meters are on the job all the time. No public utility would be considered on a sound operating basis, if its unaccounted-for product exceeded 10 per cent of its total product; yet most water departments, including even those privately operated, will show at least 40 per cent of total pumpage unaccounted for. Particularly is this the case under flat rate systems, where water consumption generally varies from 150 to 200 gallons per day per capita. Under metered rates, the consumption is, in general, 40 to 50 gallons. Thus there is four times as much water used under a flat system. This means providing reservoirs to care for a storage four times greater. Four times greater capacity is required in pumps, in purification plant, and in distributing system. Operating expense of pumping, purifying, and distributing a four fold water supply is also very considerable. In case of Baltimore, Md., it is possible to reduce water consumption from 170 to 85 gallons per day per capita. Immediately, capacity of system is doubled for same population, and, instead of assummed life of ten years before additional capital expenditures required, there would be twenty years. Present filtration plant can thus be made to supply needs of population increased by 40 to 50 per cent. If waste is not stopped, plant must be increased. Cost of new units for filtration plant will exceed investment in meters. Cost of wasted water is much greater than the fixed and operating charges of a meter system. Cost of purchasing and installing would be distributed over a five-year period, whereas deferring use of meters reduces margin between ample and insufficient supply. The city would have protection, in addition, against cost of handling extra sewerage caused by the present waste. City departments as well as private users, waste water under present system.—*Geo. C. Bunker.*

A New Automatic Valve that Regulates Flow. F. JOHNSTONE-TAYLOR (England). Fire & Water Eng., 74: 350, August 22, 1923. A new design of valve to prevent excessive flow of water through a main. The pipe line is considerably contracted at point of insertion of valve, and utilizing Venturi meter principles, closure at any desired rate of flow is ensured. By means of a Pitot tube connection, a break on down stream side will close the valve. Illustrated.—*Geo. C. Bunker.*

New Filtration Chamber. Fire & Water Eng., 74: 359, August 22, 1923. A newly invented filtration chamber is constructed of cast iron panels, with inner surfaces enameled, so that tendency to become coated is reduced to minimum, and surfaces can be cleaned at minimum expense. Edges of the panels are flanged, can be readily machined and drilled, so they can be bolted together with simple packing strips between, and water tight joints secured. Illustrated.—*Geo. C. Bunker.*

Some Practical Pointers on Rapid Sand Filter Operation. WILLIAM D. HATFIELD. Fire & Water Eng., 74: 395, August 29, 1923. A nontechnical paper for the water works superintendent who is not a chemist.—*Geo. C. Bunker.*

Sewage Works Analysis and Standards of Purification. J. H. GARNER. Surveyor, 61: 393–5, 1922. The Royal Commission Test, comprising absorption of dissolved oxygen in five days at 65°F., was studied at length, using dilution water from various sources. It was impossible to get concordant results when different dilution waters were used, even though the pH was adjusted to the same valve. Higher results were obtained at a pH of 9.0 than at 6.5. Distilled water, however, gave high results at a pH of 6.0. Blank tests on all dilution waters showed no appreciable loss of oxygen. The difficulty seems to be in the composition of the water used. The use of distilled water seems desirable.—*F. W. Mohlman.* (*Courtesy Chem. Abst.*)

Progress in Water Purification. A. C. HOUSTON. Surveyor, 61: 407–10, 1922. Houston claims it is frequently difficult to get first-class bacteriological results with rapid sand filters, and advocates double filtration, such as, preliminary filtration with rapid filters at 100 to 200 gallons per square foot per hour, without coagulants, followed by slow sand filters at an increased rate of 3 to 6 gallons per square foot, per hour. Storage is very effective in purifying the Thames River water in the Chelsea reservoirs. Experiments indicated that typhoid bacilli could not be isolated from this water after from five to nine weeks, although initially, millions per cc. were present. "Cultivated" or sub-cultured bacteria were much more resistant than those freshly isolated from feces. At temps. below 10°C., typhoid bacilli were isolated after eight weeks; at 18°C., not after three weeks. Algal growths are troublesome in stored waters, but tastes and odors produced by them can be removed by adding five pounds potassium permanganate per million gallons. The algae are destroyed best by copper sulphate. Excess lime sterilization is effective for bacterial removal, but has not been used as widely as chlorination. Houston recommends super-chlorination followed by de-chlorination with sulphurous acid or $KMnO_4$.—*F. W. Mohlman.* (*Courtesy Chem. Abst.*)

Selection of Pumping Equipment for Station Economy. Frank A. Mazzur. Amer. City, 30: 133-136, 1924. (From paper before New England Water Works Assn.) Discusses relative merits of small pumping units (about 3 m.g.d.) of various types including (*a*) Crank and fly-wheel, (*b*) Steam Turbine, (*c*) Water-Driven Plunger, (*d*) Direct-connected centrifugal, (*e*) Oil engine drive. Comparative cost estimates are given, based on eight, sixteen and twenty-four hours operation. Assuming 12 per cent depreciation on steam units and 15 per cent on other types, with coal at $8.50 and electricity at 2, 1.7 and 1.64 cents per kw.h. respectively, there is little choice on eight hour basis; on sixteen hour basis, oil engine is most economical, with steam next: on twenty-four hour basis oil engine saves $3,000 per annum over steam equipment, and $9000 per annum over electric pumping. Detailed cost figures accompany the paper.—*W. Donaldson.*

Typhoid Fever Death Rate Lower than Ever. Anon. Amer. City, 30: 136, 1924. Figures quoted from Department of Commerce, as of December 28, 1923, show decline of typhoid death rate from 35.9 per 100,000 population in 1900 to 7.5 in 1922, some progressive cities have rate of less than 1 per 100,000.—*W. Donaldson.*

Modern Carthage Builds a Forest. G. H. Collinwood. Amer. City, 30: 147-149, 1924. Describes the program under which village of Carthage, N. Y., is reforesting its water works catchment area of 2000 acres. Denuded area, acquired twenty years ago, eroded badly, filled reservoirs with silt and necessitated construction of settling basins. In 1913, 20,000 four-year-old transplants of Scotch pines, obtained from nurseries of State Conservation Commission, were made at cost about $8.00 per acre. Recently, several thousand white pines have been planted, with special precaution against the blister rust. Trees are planted 6 ft. apart, in rows, making about 1210 per acre. At present 500 acres have been planted, but program calls for reforestation of entire watershed within next ten years. Area expected eventually to yield a million feet of lumber annually. Author includes information regarding other reforestation work in New York State, based on investigation by Bureau of Municipal Research. Twenty-six cities control 220,000 acres in connection with water supplies. Of this acreage, 8000 acres have been reforested by municipalities; 80,000 acres are wooded; 3000 acres are farm land; 130,000 acres need to be reforested. Estimated cost of latter is $1,000,000, while estimated yield, at end of 40 years, is 2,600,000,000 board feet of lumber, worth at current prices $39,000,000, or $975,000 per annum. An acre of forest should yield continuously 500 board feet per annum. Reforestation protects the water supply and brings a monetary return, besides esthetic advantages.—*W. Donaldson.*

Relation of pH to Filter Plant Control.. Wm. D. Hatfield. Ind. Eng. Chem., 14: 11, 1038, November, 1922. Quantity of alum required to produce distinct floc in water is governed primarily by H-ion concentration (pH) and not by matter in suspension (turbidity). pH values of raw water at Highland Park, Mich., vary from 7.7 in winter to 8.4 in summer. During

summer, coagulation begins at pH. 7.8 and is fair at 7.6. In winter, pH must be reduced about 0.2 to 0.3 below the summer figures to produce a similar floc. Most satisfactory zone of coagulation was between pH 7.6 and 6.6, but from standpoint of maximum efficiency of plant operation, pH 7.2 to 7.3 was best. Since raw water is not highly polluted, it is more economical to operate plant at about pH 7.4 to 7.6, thereby using less alum and a little more wash water. Gillespie's method (J. Am. Chem. Soc. 42: 743, 1920) of pH determination, "without buffers," is recommended for water works laboratories. Two sizes of filter sand are in use at the plant; Red Wing, effective size 0.44 mm., uniformity coefficient 1.50, and Cape May, effective size 0.34 m., uniformity coefficient 1.62. Both gave same efficiency in bacterial removal, but longer runs were obtained, and less wash water used, with the coarser sand. (NOTE: This water does not contain color).—*Linn H. Enslow.*

Radio-activity of Waters Examined in the Bureau of Chemistry. W. W. SKINNER AND J. W. SALE. Ind. Eng. Chem., 14: 10, 948, Oct. 1922. From results in case of all waters, foreign and domestic, which have been analyzed, and also from published data, it may be concluded that shippers are not justified in making statements on labels which could induce prospective consumers to purchase the waters because of their radioactivity. The greatest radioactivity of a temporary nature was found in a water from a warm spring in Massachusetts. Permanent radioactivity was found in greatest measure in deep well in northern Ohio. To obtain daily dose (2 micrograms) prescribed by American Medical Association as a minimum, patient would have to consume 2810 gallons of the warm spring water or 1957 gallons from the Ohio well. —*Linn H. Enslow.*

Effect of Hydrogen Ion Concentration upon Precipitation of Vegetable Tanning Materials. J. ARTHUR WILSON AND ERWIN J. KERN. Ind. Eng. Chem. 14: 12, 1128, December, 1922. Rate of filtration of tan liquors is markedly affected by change in hydrogen-ion concentration. A solution of quebracho extract used for the experiment contained 67 per cent tannin, 8.8 per cent insoluble matter, and had pH value of 4.6. Lowering of pH with hydrochloric or sulfuric acid *increased* insoluble matter and rate of filtration. Raising of pH with alkalies resulted in a *decrease* of insoluble matter but an *increase* in the rate of filtration, both proceeding continuously in case of sodium hydroxide. With lime, instead of soda, as the alkali, an abrupt change occurred at neutral point, pH 7.0: further addition of lime continuously precipitated tannin in *increasing* amounts: rate of filtration received a "jolt" at pH 7.2, rapidly falling off to one-third, with rapid clogging of filter until reaching pH 8.2: at this point, a reversal set in and rapid *increase* was observed: at pH 9.2, the whole of the loss had been regained. Further addition of lime to pH 10.55 increased rate of filtration only slightly, but insoluble matter increased to 80 per cent above that at pH 9.2.—*Linn H. Enslow.*

Water Supplies of the Panama Canal. GEO. C. BUNKER. Water and Water Eng., January 1923. The U. S. Government, through Municipal Engineering Division of The Panama Canal, operates three water purification plants which

supply the cities of Panama (59,458 population) and Colon (29,000 population) and the Canal Zone towns, villages, military reservations and naval bases (27,700 population). To this relatively constant population of 116,158 must be added the shipping which passes through the Canal and takes sterilized filtered water at Cristobal or Balboa. The average supplied to ships in 1922 was 9,000,000 gallons per month. Colon and Panama are 100 per cent metered at the services, as well as through a large Venturi Meter; 88,458 people are supplied through 3,650 services with, on an average, 4,890,000 g.p.d. The per capita consumption is 57 g.p.d. which stands out in bold contrast to the per capita consumption of 280 g.p.d. in the Canal Zone which is not metered, where 27,700 people consume 7,700,000 gallons per day. Filter plant capacities are (1) Miraflores, 17.0 m.g.d.; (2) Mt. Hope, 8.0 m.g.d.; (3) Agua Clara 2.5 m.g.d. Miraflores filters have false bottoms of concrete through which project ⅜ in. brass pipes on 6 inch centers into filter. The ends of these pipes are bent downward at 180°. Brass strainers originally attached to each pipe have been removed entirely. Original gravel bed was replaced with one 24 inches in depth, using as first layer, hand placed gravel of 2½ inches diameter and larger. Seven years of service have shown the Miraflores false bottom filters to be a success. Effective washing is maintained with less than 3 per cent of wash water. Contrary to expectation, algae in Canal Zone reservoirs have never caused particularly objectionable tastes or odors, although at times responsible for very short filter runs. None of the watersheds feeding the storage reservoirs are inhabited. A caretaker and gang are continuously employed in keeping feeder streams and shore line clear of growths. The most serious matter affecting deep tropical reservoirs is the presence of putrefying organic matter at 10 feet, or more, below the surface. By far the least desirable raw water is that from Agua Clara Reservoir. Color will vary from 8 to 152 parts, iron from 0.21 to 3.0 parts, and oxygen consumption value from 1.2 to 9.8 parts. Treatment is: soda ash at rate of 37 pounds per million gallons applied to raw water main 200 feet back of aerator: alum at 350 pounds per million gallons applied 17 feet back of aerator. Treated water then passes aerator, mixing chamber, and coagulation basins. For most effective coagulation, a pH of 5.5 is maintained, with a resulting 4 p.p.m. alkalinity (erythrosine) and 4.5 parts free CO_2. After filtration, lime equivalent to 15 parts of alkalinity is applied; a pH. of 9.0, with 5 parts of $CaCO_3$ resulting. Chlorination of the filtered water is practised at all three plants. Lead is attacked by Agua Clara filtered water (pH 9.0); old pipe (0.10 p.p.m. lead in tap water) much less than new (0.5 p.p.m. lead in tap water). Lead services, therefore, are not approved. Chemically, the Canal Zone filtered waters are all that could be desired for domestic or industrial use. Cost of purification per 1000 gallons runs as follows: 1.45 cents at Mt. Hope; 2.79 cents at Miraflores; 3.73 cents at Agua Clara. A graduate chemist or engineer is placed in charge of each plant as resident superintendent.—*Linn H. Enslow.*

Utilization of the Salts of Organic Acids by the Colon-Aerogenes Group. Stewart A. Koser. Jour. Bacteriology, 8: 5, 493, September, 1923. Many organic acids offer source of carbon sufficient to support development of organisms of colon-aerogenes group. Media containing a source of nitrogen,

certain inorganic salts, and organic acids or their salts, but no other source of carbon, will support growth of one or another of this group. Sodium salts of acetic, succinic, malic, lactic, mucic, and glyceric acids support abundant growth of all colon and aerogenes cultures. Others, *n*-valeric, isovaleric, *n*-caproic, oxalic, salicylic, and ortho-phthalic, did not support growth and gave negative results. Several acids support growth of fecal B. coli, but not of aerogenes, and vice versa. Propionic acid permitted a moderate growth of most fecal B. coli strains while the B. aerogenes cultures, with one exception, were negative. The most striking results are obtained from citric acid, in which fecal B. coli consistently failed to develop, while B. aerogenes multiplied readily. The hydrogen-ion concentration of the media was reduced by aerogenes (pH 6.8 increased to pH 8.4 to 9.0), while media inoculated with B. coli were unchanged. Citrate somewhat retards the rate of growth of aerogenes. Citrate concentrations of 0.10 to 0.50 per cent were found to be the most desirable range. Below this, insufficient carbon is supplied; above it, inhibition is too great. Sodium, ammonium, or potassium citrates produce identical results.—*L. H. Enslow.*

Penetration of Bacteria Through Capillary Filter Spaces. Stuart Mudd. Jour. Bacteriology, 8: 5, 459, September, 1923. When a liquid containing bacteria is drawn through a filter under circumstances in which a few organisms may or may not pass, motility may be a critical factor in determining passage. Motility aids passage, both in purely mechanical ways, as well as by combating tendency of organisms to adhere to pore walls. Vibrio comma repeatedly showed itself able to pass, by its own powers of growth and locomotion, through a layer of sand in shorter time than V. percolans. V. comma is held back by a Berkefeld filter, while V. percolans passes, because the comparatively small size of the latter offsets its lesser power of locomotion. The intergranular diameters are therefore of critical importance in determining the penetrability of filters by bacteria. Tortuosity, length of passage, and adhesion, as well as narrowness of passage doubtless play their part in holding back bacteria.—*L. H. Enslow.*

Sanitation in Minnesota: Report of Committee on Sanitation, Minn. Surveyors' and Engineers' Society. The Bulletin, Minn. Federation of Architectural and Engineering Societies, 8: 10, 18, October, 1923. During 1920 and 1921 water service connections in cities and villages of Minnesota increased at rate of 4.5 per cent per year. Approximately 400 public water supplies in the state; 38 supplies from lakes or streams, wholly or in part, 20 receiving treatment, and 18 none. Untreated supplies dangerous from health standpoint; State Board of Health urges substitution of underground sources or treatment. Several untreated supplies were undergoing sanitary betterment at time of report.—*E. S. Chase.*

Report of Bureau Sanitary Engineering. C. G. Gillespie, Director. Quarterly Bulletin, California State Board of Health, January–March, 1923, p. 37. In damage suit against city of Pittsburgh, Cal. on account of the typhoid in that city during June and July, 1920, due to neglect in keeping chlorin-

ation works in comission, Judge Plummer of Superior Court held it incumbent upon city to use all reasonable precautions to render the water fit and wholesome and to give it treatment necessary. Damages were awarded in the amount of $32,921.29. (*Cf.* JOURNAL, 10: 6, 1140; 11: 2,503.)—*E. S. Chase.*

The Liability of Municipalities for Typhoid Resulting from Polluted Water Supplies. Indiana State Board of Health, Monthly Bulletin 26: 5, 67, May, 1923. Abstract of decision of Supreme Court of Minnesota. Court held that city of Mankato was liable for negligence in operation and pollution of its water supply, and was subject to damages. Court in its decision stated "It is obvious that a sound public policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water; nor does it appear why the the citizens should be deprived of the stimulating effects of fear of liability on the energy and care of its officials, nor why a city should be exempt from liability when a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged." Case of Keeler and Flannagan vs. City of Mankato.—*E. S. Chase.*

How Conn. Safeguards Water. Conn. Health Bulletin, 37: 11, 17, November, 1923. Brief popular exposition of chlorination of public water supplies.—*E. S. Chase.*

Odors and Tastes in Water. Conn. Health Bulletin, 37: 12, 22, December, 1923. Popular explanation of sources of tastes and odors in water supplies.—*E. S. Chase.*

Report on the Examination and Control of Water Supplies. Biennial Report, State Board of Health of New Hampshire, 1921–1922, p. 21. Work covered analyses of water samples and inspections of supplies. Special attention paid to lead and zinc content. 380 samples examined for lead; of which 71, or 18.7 per cent showed quantities in excess of 0.5 p.p.m. Supplies certified for railroad use are listed. Since 1901, general sanitary improvements on watersheds have been instigated; 7 municipal plants and 16 chlorination apparatus have been installed. Considerable detail given relative to public water supplies of New Hampshire, particularly that of Manchester. State Board requires double check valves between industrial supplies and public supply mains where cross connections exist.—*E. S. Chase.*

Report of Division of Engineering and Sanitation. Ill. State Dept. of Public Health, 5th report (year ending June 30, 1922), p. 103. Outline of work of division in connection with sanitary protection and improvement of public water supplies in Illinois. Graphical presentation is made of population served by public water supplies by decades. In 1922 some 494 municipal or institutional water supplies in Illinois served population of approximately 4,700,000. Special efforts were made by Division to assist in operation of water purification plants. During year covered, there was but one outbreak of water borne dysentery, and one of typhoid. Report contains summary of action taken relative to certification of water supplies for railroad use.—*E. S. Chase.*

Control of Stream Pollution. C. F. Dalton. Michigan Public Health, 11: 8, 305, August, 1923. Reprint of report of Committee on Sanitary Engineering, conference of State and Provincial Health authorities, Washington, D. C., May, 1923; from Amer. Jour. Pub. Health, August 1923.—*E. S. Chase.*

Public Water Supply. H. E. Miller. Health Bulletin, N. Carolina State Board of Health, 38: 6, 8, January, 1923. Deals with quality of water supply; extracts from laws of North Carolina, covering sanitary control and protection of public water supply. Board of Health has general oversight, and authority to make rules and regulations to prevent contamination of, and to secure purification for, water supplies. Disobedience to rules and regulations are punishable by fine or imprisonment. Water supply and sewerage plans must be approved by the Board.—*E. S. Chase.*

The Business Side of Public Supply. H. E. Miller. Health Bulletin, No. Car. State Board of Health, 38: 11, 15, November 1923. Points out magnitude of water supply business of North Carolina. 152 water supplies in the state represent combined investment of $25,000,000 and annual revenue of $2,500,000. Includes map of North Carolina, showing location of its public water supplies, and giving condensed data relative to sources of supply, treatment afforded, and laboratory control.—*E. S. Chase.*

New Health Laws and Regulations of Ohio. Ohio's Health, 14: 1, 2, and 3, January, February and March, 1923. Sections relating to water supply are given on pp. 10–14; those relating to railroad water supplies on p. 29.—*E. S. Chase.*

West Virginia's Progress Toward Pure Water Supplies. E. S. Tisdale. Quarterly Bulletin, West Va. State Dept. of Health, 10: 13, 217, July, 1923. Popular article, showing improvement in water supplies in West Va. in past few years.—*E. S. Chase.*

First Biennial Report by the State Dept. of Health of Washington, 1921 and 1922. Report of sanitary engineers, pp. 101 seq. Includes regulations of Department, governing water supplies and sewage disposal. Lists water and sewage purification works in State, and describes in considerable detail many of the public water supplies. It is interesting to note that State Health Dept. of Washington institutes through office of prosecuting attorney, criminal action against water companies failing to obey orders relative to installation of purification plants. Double check valves of the F. M. type, for separation of auxiliary mill supplies from municipal supplies, appear to be approved. Typhoid death rate in Washington was 5.6 in 1921, and 5.0 in 1922, per 100,000 population.—*E. S. Chase.*

Special Report Relative to Water Supply for the City of Lawrence and the Town of Methuen. Mass. Dept. of Public Health, March, 1923. Legislature in 1922 directed Department of Public Health to investigate water supply needs and resources of City of Lawrence and town of Methuen, and to determine

best method of supplying these municipalities with water and protecting the purity thereof. Developing of nearby streams, other than the Merrimac, is not advisable at present, on account of cost. The possible development of joint project, to include other nearby municipalities, is discussed. More extended investigation is recommended.—*E. S. Chase.*

The Treatment of Municipal Water Supplies. N. J. Public Health News 9: 2, 51, January, 1924. Good general discussion of water treatment with special reference to New Jersey conditions.—*E. S. Chase.*

The Operation of Wheeler Filter Bottom. N. J. Public Health News 9: 2, 64, January, 1924. Discussion of above, as installed at two filter plants in N. J. At one plant, after 18 months operation, cement spheres were found to have changed into a variety of irregular figures. In making repairs, cement spheres are replaced by earthernware spheres of same diameter, and gravel is increased from 6 to 12 inches.—*E. S. Chase.*

Water. Geo. W. Simons, Jr. Fla. Health Notes, 16: 2, 24, February, 1924. General discussion of water supply, with some data relative to underground waters in Florida.—*E. S. Chase.*

Present Day Practice in Chemical Treatment of Water (in Holland). Dr. A. Massink. Water en Gas, January 15, 1924. Many interesting and important refinements, introduced in recent years, find but small applicability to conditions in Holland, where, frequently, water as pumped from the well is either quite suitable for consumption, or can, without difficulty, be rendered so by removal of iron and/or manganese. The stimulus to improved practice, so notable in America, is largely lacking. Chemical treatment is conveniently classified as: A, removal of undesired constituents, without addition of chemicals; B, same; with addition of chemicals; and C, sterilization. Foremost under A belong deferrization and demanganization. To Oester and Piefke, respectively, we owe the principles of spraying and of coke percolation. In most cases, these suffice, when followed by, first, either sedimentation basins or roughing filters, and then, fine sand filters: but some waters are refractory. Sedimentation may be conveniently studied in a cask in which are suspended a series of siphons set to different depths, rendering available at any time a sample from any desired stratum. The iron, evenly distributed at the start, will, in general, concentrate towards lower levels with lapse of time. In the case of one water examined, notwithstanding very imperfect sedimentation, a faultless filtrate resulted; representing a transition case between those waters from which iron readily flocks out and those from which it cannot be removed without adding chemicals (class B). Iron removal is, largely, a colloid chemical problem. Flocculation tends to be retarded by low electrolyte concentrations, and accelerated by higher, which imply, usually, preponderance of bicarbonate among the anions present. Notable among other factors, is the highly prejudicial influence of certain organic substances. Demanganization is the more difficult problem; adjustment of hydrogen-ion concentration is here important. Explanation is offered of known advantages of "manganese sand"

which has already served for demanganization. Like iron, manganese tends to be more difficult to get rid of, according as preponderance of bicarbonate diminishes; as with iron, too, addition of chemicals may eventually be needed. Carbonic acid yields to intensive aeration, and both oxygen and carbonic acid, to vacuum degasification (sometimes necessary for soft water, which easily becomes aggressive). For iron-free soft water, aggressivity removal is conveniently effected by Scheelhaase's method of using marble in supporting layers under filter; this might perhaps be more appropriately included under next heading. Under B, softening processes are most important, either (1), lime—soda, leaving a small residual hardness, or (2) permutite, leaving zero hardness. Alum coagulation is usual practice for decolorization. Both turbidity and color, but especially former, range considerably higher in America than in Holland, and opportunity is taken to render tribute to work done on coagulation in America, this JOURNAL receiving special mention in this connection. Lack of concordance in conclusions reached is still apparent. Clark's new process and iron—lime coagulation are described. Under C are discussed ultra-violet radiation, ozonization, and chlorination; last-named, at some length. Supplies needing sterilization are comparatively infrequent in Holland, and progress of chlorination, correspondingly slow. American work on chlorination and its control is duly appreciated. Advantages of Chlorination for swimming pools are pointed out. Finally, Houston's "excess lime" method receives mention. Bibliography includes 11 references.—*Frank Hannan.*

Hydrobiological Conditions in Rijnland (Holland). DR. G. ROMIJN. Verslagen en Meded. betref. de Volksgezondheid, 1924, 2, 107. A more or less occult phase of the ceaseless strife for her existence which Holland has to wage with the inexorable North Sea, is here revealed; namely, invasion by salt water of her innumerable waterways. This tends to render the water useless alike for domestic supply, industry, agriculture, or live stock; and the added sulfate is readily convertible into highly offensive sulfuretted hydrogen. The pure dune supplies are limited, and therefore precious; they must be guarded by the utmost possible utilization of surface water. The results of hydrobiological surveys are detailed, and their great value pointed out as indicators of zones where brackish water is being pushed back and vice versa, etc. Every available centimeter of head is jealously watched and made to do its utmost in keeping out the enemy. Opinion is expressed that, from the hygienic standpoint, almost no expense could be too great, which would effectually bar out the salt water.—*Frank Hannan.*

Chlorination of Water. DR. A. MASSINK. Tijdschr. v. Vergelijkende Geneesk. enz., 9: 1–2, 1923. Widespread adoption in America and Germany is noted; is now coming into use in Holland. Quantitative tests on Maassluis supply indicated that dosage at rate of either 0.3 or 0.5 p.p.m. would reduce bacterial counts to negligible limits in course of thirty to sixty minutes; in the case of smaller, but not of larger, dose, vigorous aftergrowth manifested itself within twenty-four hours. Since ferrous iron, if present, is at once oxidized to ferric, at expense of chlorine, it is logical that deferrization precede chlorina-

tion. Two series of taste tests, with eight and nine observers, respectively, resulted in correct decisions as to presence or absence of chlorine, with dosages of nil and 0.5 p.p.m. in both series, and intermediate dosages of 0.3 and 0.25 p.p.m., respectively, in just over 60 per cent of trials in each case. Considerably rarer was the ability to distinguish lesser from greater chlorine dose.—*Frank Hannan.*

NEW BOOKS

The Chemical Examination of Water, Sewage, and Foods, Etc. J. E. Purvis and T. R. Hodgson. 2nd. ed. revised. Cambridge: University Press. 20s. Reviewed in Chem. Trade J., 70: 600, 1922 .From Chem. Abst., 16: 2379, July 20, 1922.—*R. E. Thompson.*

Boiler Chemistry and Feed Water Supplies. J. H. Paul. London: Longmans Green & Co. 252 pp. 15s. Reviewed in Municipal Engineering, 73: 84, 1924.—*R. E. Thompson.* (*Courtesy Chem. Absts.*)

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VOL. 11 JULY, 1924 No. 4

CAST IRON PIPE PRICES[1]

BY F. G. GORDON[2]

Cast iron pipe constitutes the largest single element of value of the average water works. The price of cast iron pipe therefore is of decided interest to the superintendent, the engineer and the appraiser.

The appraiser may be, and usually is, interested in past prices of cast iron pipe. The superintendent and engineer are much more interested in present and future prices. Will cast iron pipe remain at or near its present price for some time to come, or may we expect a return to pre-war prices within a reasonably short period of time, or will the price trend be somewhere between these two extremes? It would be an imposition on your intelligence and a reflection on his own for the writer to attempt to predict with accuracy the future price of cast iron pipe. It is possible, however, to analyze the elements which go to make up its cost and thus gain an idea of the way in which changes in these elements will affect prices.

For this purpose a consideration of past prices becomes necessary.

Figure 1 shows the price of 6-inch cast iron pipe at Chicago for the twenty-year period from 1904 to 1923, inclusive. It also shows the price of Southern No. 2 pig iron at Birmingham for the same period.

[1] Presented before the Illinois Section meeting, March 20, 1924.

[2] Hydraulic Engineer, Maury and Gordon, Chicago, Ill.

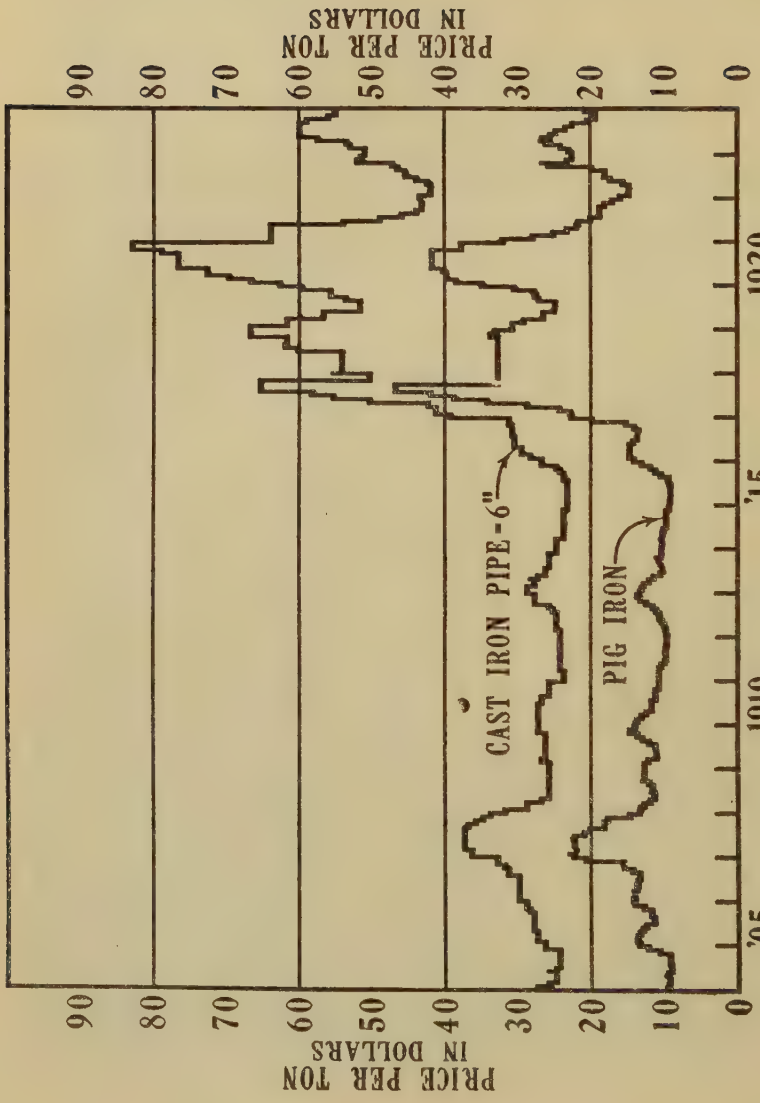
PRICE PER TON IN DOLLARS
90
80
70
60
50
40
30
20
10
0
'05
1910
'15
1920
YEARS
CAST IRON PIPE-6"
PIG IRON
PRICE PER TON IN DOLLARS

FIG. 1

Six-inch pipe in 1903 reached a price of $35.00 f.o.b. Chicago, and in the spring and summer of 1907 exceeded this somewhat with a top price of $37.50. The ensuing financial depression caused a rapid decline so that by May, 1908, 6-inch pipe was selling for $26.00 per ton. From this date until 1916, or for a period of nearly eight years, the price of pipe fluctuated but little. However, starting with 1916 the fireworks began. Peak price followed peak price until in October, November and December of 1920 6-inch cast

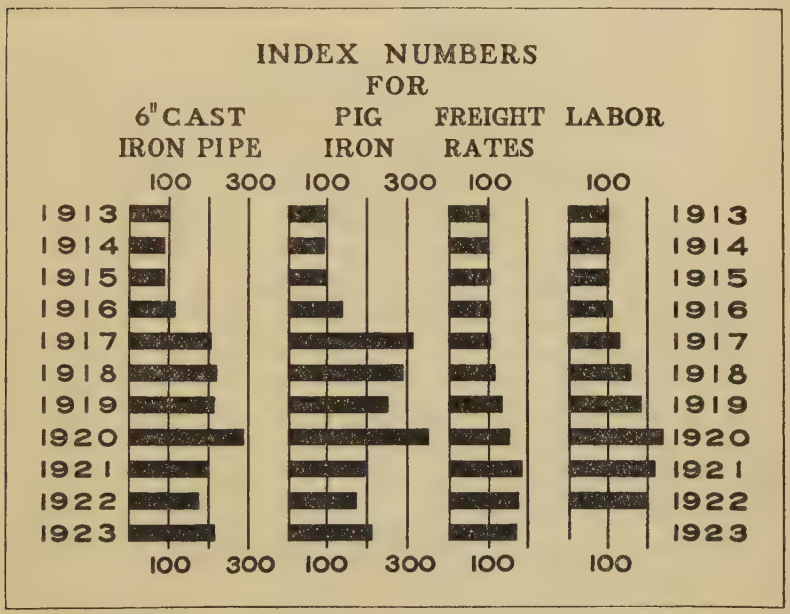

Fig. 2

iron pipe was quoted at the unbelievable price of $83.10 per ton f.o.b. Chicago. This peak price was followed by a rapid decline which carried the price to a figure of $43.35 just one year later. From this point the price has advanced gradually with minor fluctuation until today 6-inch pipe is quoted at $56.70 per ton f.o.b. Chicago.

This diagram well illustrates the close relation existing between the price of cast iron pipe and the price of pig iron. An increase in the price of pig iron is followed by a corresponding increase in the price of cast iron pipe, while a decline in the price of pig iron usually results in a falling off of cast iron pipe prices.

In addition to pig iron there are two other major elements which go to make up the price of cast iron pipe. These are manufacturing costs and freight rates. The variation in these factors in recent years has been almost as marked as the variation in the price of pig iron.

Figure 2 has been prepared in order to show how the change in these various factors has taken place. This diagram shows index numbers for 6-inch cast iron pipe, pig iron and freight rates from the base year, 1913, to and including 1923, and index numbers for labor from 1913 to and including 1922.

The index numbers for cast iron pipe, pig iron, freight rates and labor for the year 1913 were each assumed to be 100 and subsequent numbers were then calculated from the 1913 base. Chicago prices of 6-inch cast iron pipe, Birmingham prices of Southern No. 2 pig iron, and freight rates on cast iron pipe from Birmingham to Chicago were used in making up index numbers for the first three graphs shown. The index numbers on labor are for iron moulders and are taken from statistics issued by the Department of Labor of the United States Government. The index numbers for pattern makers and core makers are almost identical with those given for moulders. It is interesting to note that, while the index number for pig iron reached 310 in 1917, the index number for cast iron pipe in that same year was only 203. The low index numbers for freight rates and labor readily account for this. It will be seen that in 1918 and 1919 the index numbers for labor and freight rates increased perceptibly, causing a slight increase in cast iron pipe even though pig iron fell off.

In 1920 the peak was reached for cast iron pipe, pig iron and labor, while the peak in freight rates did not occur until 1921. This chart discloses the fact that, in comparison with the other three commodities shown, freight rates have had a rather moderate increase since 1913. The Department of Labor index number for 1923 for moulders was not available at the time this diagram was made, but it is probable that it was in excess of the figure for 1922.

Let us now consider what change may be expected in the near future in the factors which make up the cost of the finished pipe.

The cost of pig iron is a large element in the cost of cast iron pipe and an extremely uncertain one. Like most raw materials its price is affected to a greater extent by the law of supply and demand than is the finished product. If we are to expect a decided reduc-

tion in pig iron prices, we must expect a marked diminution in the production of iron and steel products. If one will compare the curve showing unfilled orders of the United States Steel Corporation with the curve showing pig iron prices, the correctness of this statement will be realized. The similarity between these curves is striking. Although the law of supply and demand will greatly affect pig iron prices, it must not be forgotten that freight rates and labor are two of the important elements of cost involved in the production of pig iron.

What may be expected of manufacturing costs? Skilled labor is one of the large factors here and probably enters to a greater extent than any other. A reduction in the cost of this item per unit of pipe may take place either as a result of reduction in wages or from improvements in the art of manufacturing pipe. At the present time it would appear as if the latter possibility offered the greater promise of a lowering in unit labor costs.

A process which is said to increase the production of pipe for the same number of men 100 to 150 per cent over the sand cast method has been adopted by two of the large pipe manufacturers. This is the de Lavaud process of casting iron pipe centrifugally.

The equipment required consists of a water cooled mould which can be rotated, a cantilever spout of sufficient length to extend to the end of the mould, a pouring ladle of special design, and a hydraulic ram for moving the mould in a direction parallel to its own axis.

The operation of making a pipe is this: A core is inserted and clamped into position at the bell end of the mould. This core is of the proper shape to form the bell end of the pipe. The mould is then moved forward on the spout until the end of the spout is near the bell end of the mould. The mould is then rotated and metal poured into the spout. The mould now moves away from the spout, thus combining a circular movement with a longitudinal one. During this operation the metal flows from the end of the spout into the mould, and due to the centrifugal action of the mould, is thrown to the outside, where it solidifies. It is readily apparent that with a uniform travel of the mould and with a uniform pouring of metal from the end of the spout a pipe of uniform thickness is assured.

The metal is poured into the spout from a tilting ladle, whose movement is hydraulically controlled. This insures a steady flow

of iron. After a pipe has been cast, clamps are inserted at the bell end which hold the pipe while the mould moves away from it. This results in the withdrawal of the pipe from the mould. After the pipes are cast they are moved immediately to an annealing oven in order to conserve as much of the heat as possible.

Pipe made by this process has a higher tensile strength than that produced by the sand cast method. Because of this and the further fact that a uniform thickness of wall is assured by this method, the weight of this pipe is 25 per cent less than that of standard sand cast pipe designed for the same head. This results in a saving in material and a saving in freight.

At the present time the cost of this pipe per linear foot at the foundry is approximately 95 per cent of the linear foot cost of standard pipe. The saving to the consumer comes from the fact that the weight of the pipe per foot is only about three-quarters of that of the standard pipe, which reduces his freight charges accordingly. It is probable that it will be a few years at least before the influence of this new method of manufacture makes itself felt in the price of of cast iron pipe.

It seems unreasonable to expect that there will be much of a reduction in freight rates for several years. Railroads are confronted with ever increasing taxes, with labor problems resulting from their dealing with some of the strongest labor unions in the country, and with more or less deferred maintenance, all of which factors tend to prevent a reduction in rates.

We are now in a position to sum up the various factors considered and to arrive at some conclusions concerning the future price of cast iron pipe. That fluctuations up and down will result from similar fluctuations in the price of pig iron is unquestionable. The general price trend should be slightly downward as the result of decreased manufacturing costs, but any decided decrease must await reductions in labor, freight rates and taxes.

In connection with this discussion of cast iron pipe prices, a study was made of the change in prices during the various months of the year in order to determine if there was any particular advantage to be gained financially by purchasing pipe during certain months or seasons. Over the twenty-year period from 1904 to 1923, inclusive, the lowest average price for any one month occurred in February, when this figure was $37.38. The highest average figure of $39.68 for 6-inch cast iron pipe came in December.

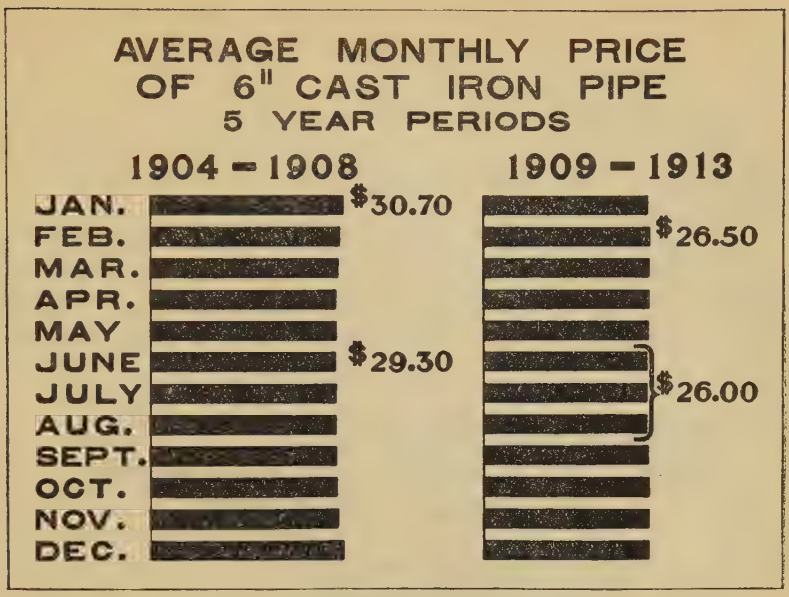
AVERAGE MONTHLY PRICE
OF 6" CAST IRON PIPE
5 YEAR PERIODS
1904 – 1908
1909 – 1913
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
$30.70
$29.30
$26.50
$26.00

Fig. 3

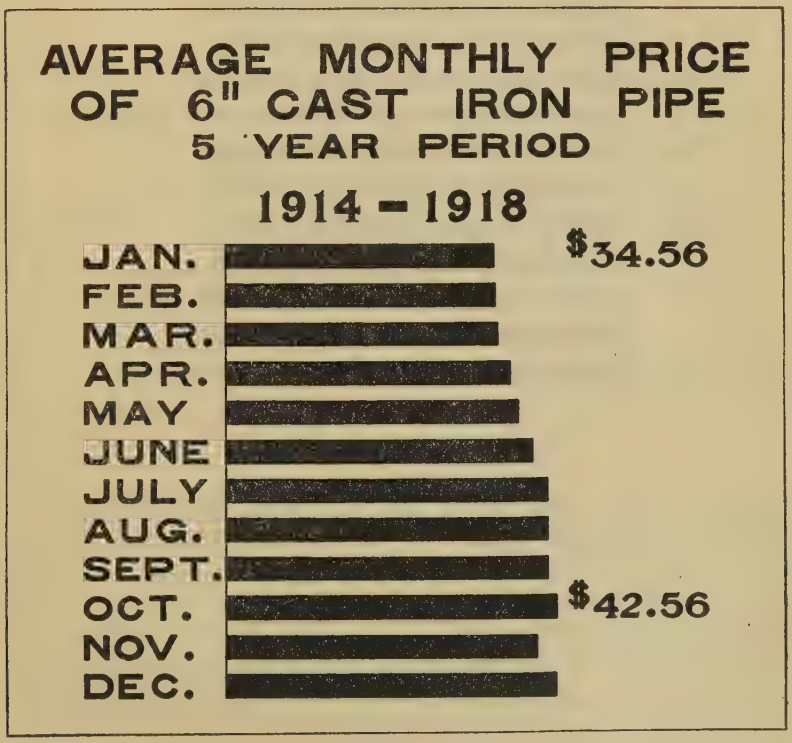
AVERAGE MONTHLY PRICE
OF 6" CAST IRON PIPE
5 YEAR PERIOD
1914 – 1918
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
$34.56
$42.56

Fig. 4

In order to study this question more closely, the average price by months of 6-inch cast iron pipe was computed for five-year periods. This study showed some interesting results which are illustrated by the following figures.

Figure 3 shows the average price by months for the five-year period from 1904 to 1908, inclusive. The January price of $30.70, for example, was computed by taking the price of 6-inch cast iron pipe in January of each of the five years and averaging it. Note

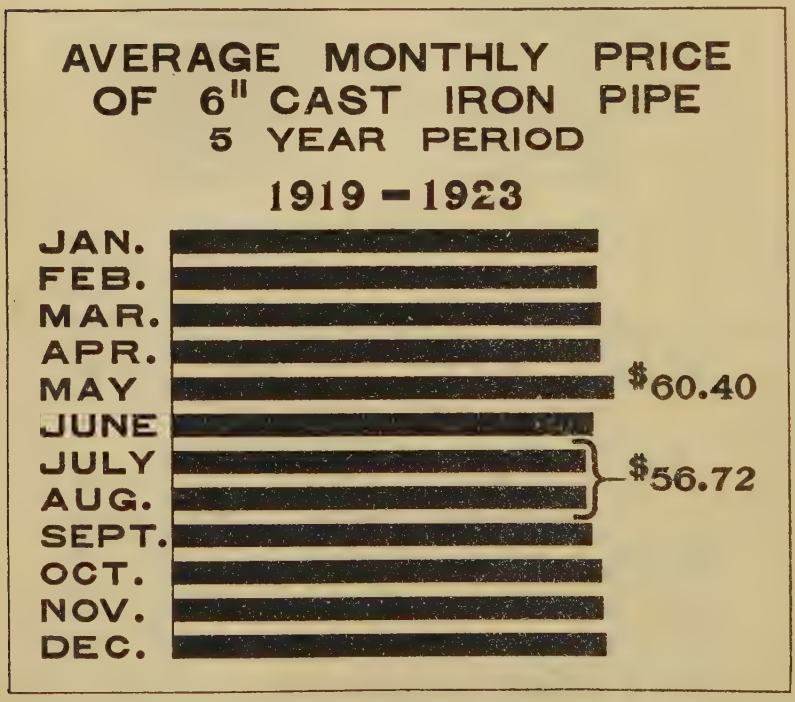

Fig. 5

that the lowest average price occurred in June, but that it was only $1.40 lower than the highest average price in January. During the five years from 1909 to 1913, inclusive, the lowest average price occurred in June, July and August.

The average monthly prices during the five-year period from 1914 to 1918 show a minimum figure of $34.56 for the month of January, and a maximum figure of $42.56 for the month of October;

or, a difference of $8.00 between the maximum and the minimum prices.

During the five-year period from 1919 to 1923, inclusive, $56.72 was the lowest average price in July and August; while $60.40 was the highest average price. This price occurred in May.

These diagrams indicate that in fifteen of the past twenty years better prices were obtained by summer purchasers, while during one five-year period January was the best month to purchase pipe.

THE FUTURE OF WATER RESERVOIR PROJECTS IN ILLINOIS AND THEIR RELATIONSHIP TO GEOLOGIC DATA[1]

By M. M. Leighton[2]

The underground water resources of northeastern Illinois are perhaps better known than in any other part of the State, due to the intensive industrial development which has gone on there. The water horizons in this part of the State belong to the lower part of our State's geologic column. They include the Niagaran dolomite, Galena-Trenton series, St. Peter sandstone, Prairie du Chien series, and "Potsdam" sandstone. The depth to the "Potsdam" sandstone ranges from about 550 feet in Winnebago County to about 1400 feet at Chicago, and the depths to the other successively higher horizons are correspondingly less.[3] Ordinarily, most of these aquifers furnish abundant supplies, but the excessive requirements in the vicinity of Chicago are a tax on nature to supply the water as rapidly as it is used, and as a result the static head is rapidly lowering. This fact has been brought out clearly by Mr. C. B. Anderson in the publication just referred to in the footnote, and with added force by Mr. Isham Randolph in his series of two articles which appeared in the *Chicago Daily News*, September 12 and 13, 1923. The proximity, however, of this territory to one of nature's largest fresh water reservoirs, Lake Michigan, reduces the apprehension which might otherwise attend this problem, but it is not true in the case of central and southern Illinois, where several municipalities have now reached a critical situation with regard to their water supply.

In central and southern Illinois many of the county seats and larger towns have heretofore drawn their water supplies from the

[1] Presented before the Illinois Section meeting, March 19, 1924.

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[3] For detailed information the reader is referred to Carl B. Anderson, The Artesian Waters of Northeastern Illinois; Ill. State Geol. Survey Bull. 34, 1919.

glacial drift. This is true of Urbana and Champaign. In the case of glacial drift, sand and gravel strata are likely to occur in old river valleys which were buried by the deposits of glacial drift. The existence of these old river valleys may not be revealed by the present topography, but may be ascertained by the assembling of well data. This is one reason why the Illinois Geological Survey stresses and appreciates the faithfulness of all drillers in sending in accurate logs of their wells. The old buried Rock River Valley of northern Illinois has been fairly well delineated and its buried gravel deposits furnish a part of the water supply of the City of Princeton. Less is known about the buried valleys of central and southern Illinois, and we are anxious to secure data on the same. Modern valley alluvium is a well-known source of supply and locally is important, as at Peoria. At Springfield, however, it is proving inadequate, and a reservoir project is being planned. Normally, drift wells are shallow, and although adequate for a while, it is only a question of time when many towns will have to look elsewhere for this great necessity. A critical situation having already developed for some of them, they are facing the question as to what other source they can draw upon. There are two possibilities: (1) deeper aquifers; and (2) surface water reservoirs. Let us examine these two sources.

CHARACTER AND STRUCTURE OF THE GEOLOGIC STRATA IN CENTRAL AND SOUTHERN ILLINOIS

The geologic column for Illinois is as follows:

Groups	*Systems*
Cenozoic	Recent
	Pleistocene
	Tertiary
Mesozoic	Cretaceous
Paleozoic	Pennsylvanian
	Mississippian
	Devonian
	Silurian
	Ordovician
	Cambrian

In the more northern part of Illinois, the Tertiary, Cretaceous, Pennsylvanian, Mississippian, and Devonian systems are largely absent,

and the Silurian and Ordovician formations outcrop at the surface, except where covered with glacial drift and recent deposits. Farther south, the Silurian, Ordovician, and Cambrian formations dip deeper and deeper as distance increases, and are buried by Devonian, Mississippian, and Pennsylvanian formations. The well driller can not help but be impressed with the notable changes which take place, especially south from the Upper Illinois River. When it is remembered that each of these systems comprises at least two formations, and in some cases, as in the Ordovician system, many different formations, and that most of these formations have thicknesses ranging from 100 to 300 or 400 feet and that their aggregate thickness is to be measured in terms of thousands of feet, we begin to conceive of the magnitude of the rock strata with which our study deals.

It is a common conception that the strata of Illinois lie flat. They appear to do so in many exposures whose horizontal extent is measurable in some scores of feet. But it does not take more than a slight departure from horizontality to bring about a considerable vertical rise or fall when distance is measured in miles rather than feet. If the departure from horizontality is no more than half a degree, this would amount to about 46 feet in one mile, or about 460 feet in ten miles, and about 4600 feet in 100 miles. Inasmuch as we are dealing with the dimensions of a State rather than a county or township, and inasmuch as our geologic formations are continuous over a great extent of territory, regardless of State boundaries, we should not be surprised to find that the geologic situation in one locality may be quite different from that in another.

To be still more specific, let us examine the accompanying map in figure 1 which shows the altitude of the St. Peter sandstone in the northern part of the State and as far south as we have knowledge. In northeastern Stephenson County, and in Ogle and Lee counties, the St. Peter sandstone reaches an altitude of approximately 800 feet above sea level. Southwest from the center of Lee County, the formation dips to lower and lower levels, passing successively the 600-, 400-, and 200-foot levels, and before reaching the southwestern corner of the county, it descends to a depth of 400 feet below sea level. Southeast from here, our best evidence indicates that it continues to descend, reaching 800 feet below sea level in central Bureau County, 1060 feet below sea level at Peoria, and more than 1400 feet below sea level in southern McLean County. Still

FIG. 1. STRUCTURE MAP OF THE SURFACE OF THE ST. PETER SANDSTONE

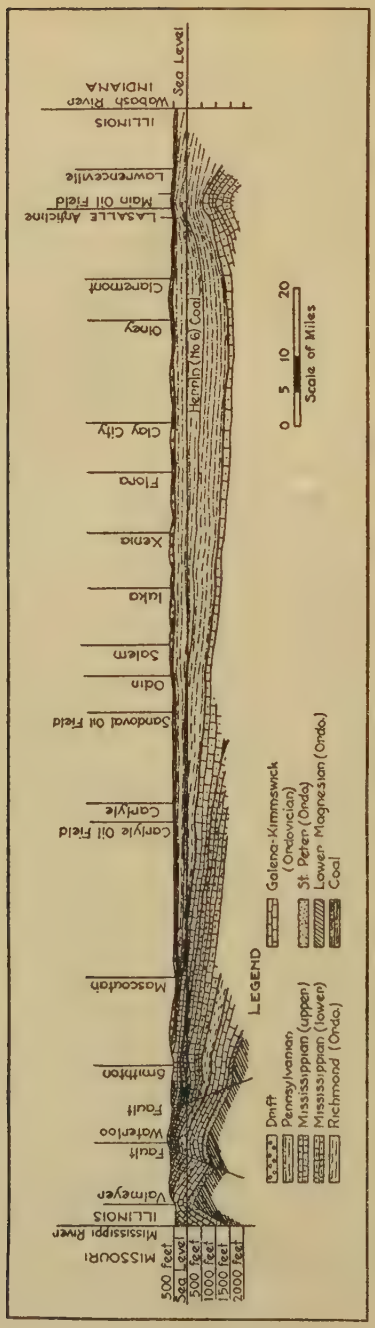

FIG. 2. SECTION ACROSS SOUTHERN ILLINOIS THROUGH MONROE, CLINTON AND LAWRENCE COUNTIES, SHOWING THE LA SALLE ANTICLINE AND THE BROAD ILLINOIS BASIN

farther south, in Perry County, the well of the Illinois Central Coal and Salt Company at St. Johns, ended at a level of about 3134 feet below sea level in the formation just above the St. Peter sandstone.

Westward in Illinois from the line just traced, the strata rise gently, but generally not reaching sea level, whereas eastward there is an abrupt rise to the crest of a fold known as the La Salle anticline which extends in a northwest-southeast direction from Lee County to the oil fields in Clark, Crawford, Lawrence, and Wabash counties. From the crest of this fold, the strata dip much more gently eastward than to the west, making the fold asymmetrical. It is to be noted that the crest of the fold declines gradually southeastward. In La Salle County, the St. Peter sandstone on the fold reaches an altitude in excess of 600 feet, above sea level, and in places underlies immediately the surface soil, whereas farther and farther south it declines to more than 2467 feet below sea level in Clark County, younger and younger formations coming in to bury it. Now changing our direction to an east-west line we note the lay of the rock formations well shown in figure 2, which is a cross-section by R. S. Blatchley, from Valmeyer on the Mississippi to Lawrenceville, near the Wabash. This figure brings out the way the formations dip in the western part of the State and the marked change which takes place at the La Salle anticline.

It is clear now that the formations west of the La Salle anticline lie in a great basin and that those strata which are a continuation of shallow strata in northern Illinois are deeply buried. The uppermost bedrock formations belong to the Pennsylvanian system and have a thickness of a few feet near the edge to 2100 feet in Clay County. Beneath the Pennsylvanian system over a considerable part of the basin the drill must penetrate the formations of the Mississippian and Devonian systems before it reaches the well-known aquifers of the Silurian, Ordovician, and Cambrian systems. What higher horizons then may be regarded as potential aquifers? Within the Pennsylvanian system the basal formation, the Pottsville, is the chief potential aquifer, but even this is doubtful, for while it is generally a sandstone formation, within short distances it may become a shale. This character, together with its small amount of voids due to the angularity of the sand grains and the presence of some clay bond, all tend to obstruct the free percolation of water and prevent it from being an aquifer of the type of the St. Peter sandstone.

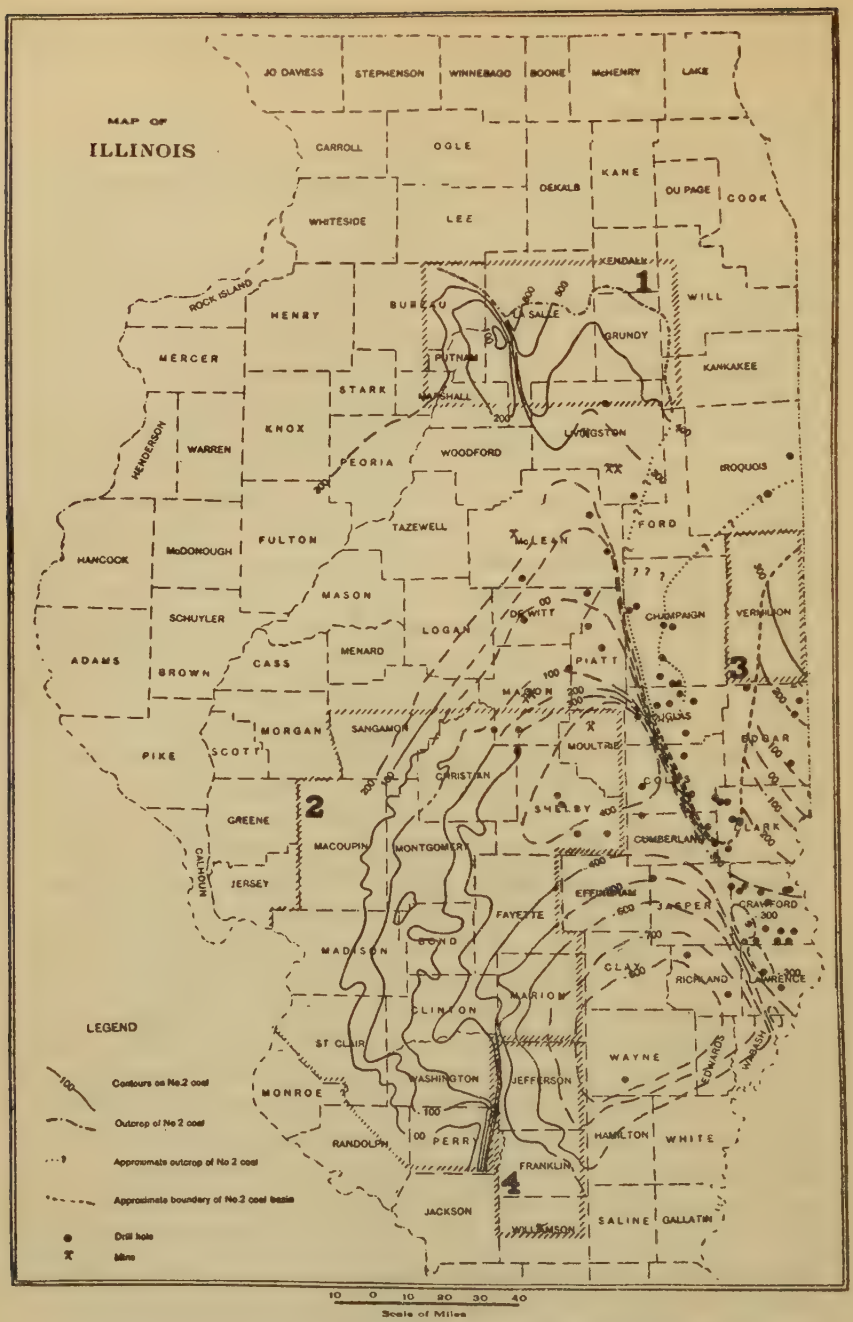

FIG. 3. STRUCTURE OF PENNSYLVANIAN STRATA ACROSS THE LA SALLE ANTICLINE, BASED UPON DETERMINED OR ESTIMATED ALTITUDE OF NO. 2 COAL

Some conception of the altitude at which the Pottsville lies may be gained from the accompanying map (fig. 3). Although the contours on this map are based on no. 2 coal which lies immediately above the Pottsville formation they may be regarded as essentially representing the top of the Pottsville. It is to be noted that from DeWitt County south the top of the Pottsville is everywhere below sea level and descends to more than 800 feet below sea level in Wayne County. While some of the Mississippian formations may be water carriers, they lie still deeper than the Pottsville.

CHEMICAL CHARACTER OF THE BEDROCK WATER IN CENTRAL AND SOUTHERN ILLINOIS

The quantity of the bedrock water and the depth at which it may be secured are only two of the important factors in the consideration of ground water supplies, the third being its quality or chemical character.

It is generally appreciated that water from the bedrock formations is never pure or free from mineral matter. In fact, there is probably no pure water in nature. But there is a considerable difference in the quantity of mineral matter which may be present in solution in the different formations and at different places, and a considerable difference in the kind of mineral matter.

Figure 4 is a map showing the locations of the various municipalities in the State which secure their water supply from rock wells. It is to be noted the greater prevalence of rock wells is in the northern part of the State. The dominant type of well in the central and southern parts is the drift well which is not shown on this map. Chemical analyses have been made of the waters of all of these rock wells, and their content of mineral residue determined in parts per million. These have been classified on the basis of quantity and so indicated on the map by symbols as given in the legend. We are indebted to Bulletin 16 of the Illinois State Water Survey for these data. It is possible that some addition to this number of wells might be made if the study were to become more intensive, but it is believed that the data at hand are adequate to show the general status of the situation.

Only 12 of the municipal wells of the State yield water with a mineral content less than 300 parts per million; 59 wells yield 300 to 500 parts per million; 60 wells, 500 to 1000 parts; 37 wells, 1000 to 2000 parts; and 14 wells yield in excess of 2000 parts. All of

those which yield less than 300 parts per million are located in the northern part of the State, excepting two, namely Mounds and

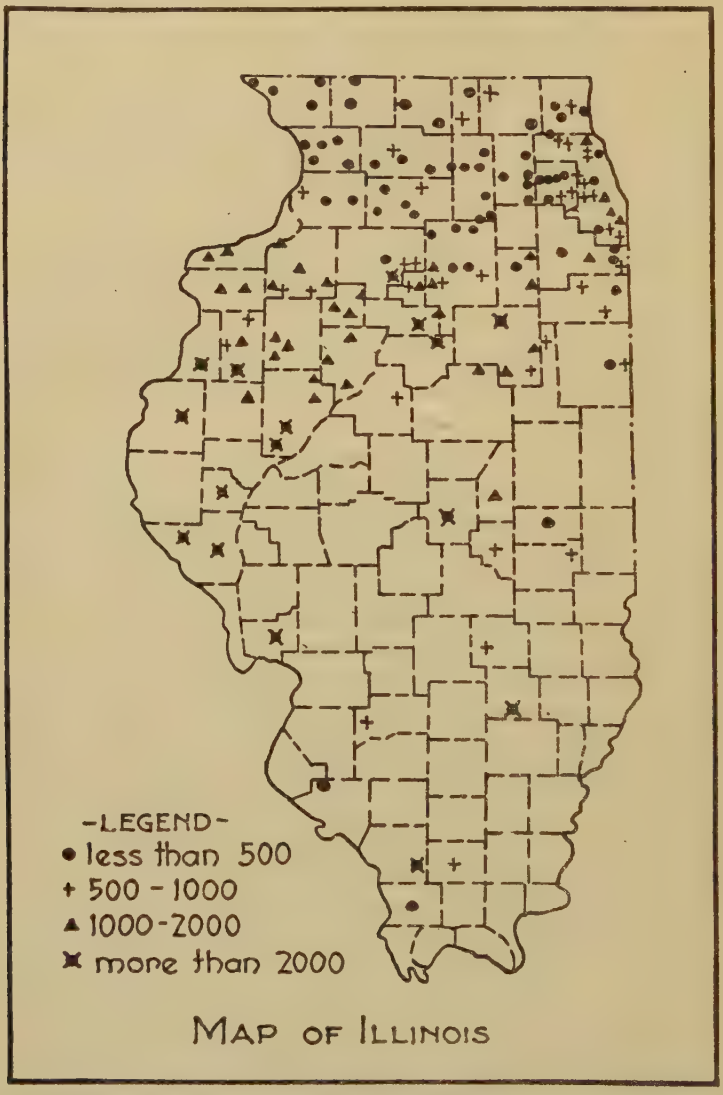

FIG. 4. MAP SHOWING LOCATION OF VARIOUS MUNICIPALITIES IN ILLINOIS THAT SECURE THEIR WATER SUPPLY FROM ROCK WELLS

Mound City which are located in the extreme southern part of the State, south of the Illinois Ozarks. None of the wells in the central

and southern parts of the State yields less than 400 parts per million, and the great majority of them yields more than 1000 parts, and at Decatur, there is a well which, according to the Illinois State Water Survey, yields 76,377 parts per million. We do not know the chemical character of the water from all of the water-bearing formations in every part of the State, and it is to be hoped that such a study can soon be made. Nevertheless it seems that the high mineral content of water from central and southern Illinois prevails without regard to any specific bedrock formation. It is, therefore, evident that drilling to the deeper horizons would be a discouraging venture, not only from the standpoint of cost, but also from the standpoint of industrial use.

WATER RESERVOIR PROJECTS

Faced with this situation, attention is being turned more and more to the development of water reservoirs, and to the treatment and use of surface water. Indeed, it appears that we are entering upon an epoch of reservoir projects. In this case, it is exceedingly important that a drainage line be chosen which has adequate runoff and which affords a natural reservoir site. Data then are required as to the extent of the area drained, the amount of slope, the steepness of slope, and the relations of such an area to sources of pollution. Where topographic maps are not available expensive preliminary surveys are necessary. In order to eliminate a large part of such expense and in order to facilitate a prompt consideration of surface water resources and plans for reclaiming the same, the Illinois Geological Survey is taking cognizance of the local needs of municipalities in formulating its program of topographic mapping. Towns which have apparently reached their crisis in respect to water supplies, and which are anticipating an early financing of a water reservoir project, are receiving special consideration in the selection of areas to be mapped at an early date.

The execution of a water reservoir project is something more, however, than a consideration of adequate surface supplies and the economic construction of a satisfactory dam to impound the same. It involves also the selection of a reservoir site after an examination that is something more than a surface inspection. The earth materials beneath the dam must be of a sort which will support the weight of the dam and will not develop weakness by virtue of an incipient condition which is prone to become hazardous under the weight of

the dam and the impounded water, as time goes by. The earth materials beneath the dam, at the ends of the dam, and in the natural walls of the reservoir must also be such as to prevent excess leakage. It is well appreciated by experienced engineers that the materials which enter into a dam may be first class in every respect, the construction of the dam may be in accord with modern standards of engineering, and that the structure itself may well invite the admiration of our engineering profession, but if it happens to be placed in a geologic environment, where, by reason of lack of strength in the materials beneath the dam or by reason of an incipient defect in the rock strata, the ideal structure is bound to give way, large sums of money will be lost, and another critical demand for water attend the catastrophe. And they further recognize that, even though the geologic foundation of a dam may be strong, the primary purpose of the dam is defeated if excess leakage takes place beneath or at the ends of the dam, or through the natural walls of the reservoir.

In order to avoid such failures as have attended some water reservoir projects elsewhere, in order to prevent the possible loss of large sums of money, in order to maintain possession of an adequate reservoir supply so necessary to the health and industrial development of any municipality, the Illinois Geological Survey is prepared to coöperate to the full extent of its prescribed functions with the municipalities involved, and is ready to place at their disposal such information and facilities as it has available. It is prepared to give advice regarding the character of the preliminary tests to be made, in regard to the proper recording of the results of such tests, and in the interpretation of the data acquired. It is recognized that almost every new locality has a different set of geological conditions, and a special consideration of each is therefore imperative.

WATER WORKS AND THE FIRE PROTECTION OF SMALL MUNICIPALITIES[1]

By Charles W. Parsons[2]

Engineers in designing new water supply systems and in laying out improvements and extensions for existing systems, and superintendents in planning and supervising improvements in their own water works, are confronted with many problems. The fundamental problem is to furnish the best possible service for the least possible cost. This service should meet the requirements of both the domestic consumption and adequate fire protection.

In the small municipalities the requirements for fire protection often are not appreciated and consequently are greatly underestimated or sometimes almost entirely ignored. The average small city fortunately has comparatively few fires per year and the aggregate of high values in the mercantile district is proportionally less than in the larger business centers. These two features tend to give the citizens a false sense of security and often of indifference to the need of reliable fire protection. The domestic use of water is an almost involuntary part of the every day program in the home and place of business, and any slight irregularity or brief interruption of the usual pressure or quantity is given immediate attention and proper steps are taken to prevent a recurrence. The principal function of the water system, as casually defined by the ordinary citizen, would then seem to be the supplying of pure water in quantities sufficient for the domestic consumption. The question of providing fire protection would consequently appear to be an important, although secondary, consideration. It would follow naturally that the design and enlargement of water works should be made in such a way as to fulfill most economically and satisfactorily the requirements of this purpose for which it is apparently maintained. Engineers and superintendents, of course, comply with the wishes of the citizens and make the necessary provisions and extensions for

[1] Presented before the Illinois Section meeting, March 19, 1924.

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maintaining the best possible service to the consumers, with the funds available. Whatever surplus money and equipment can be obtained is put to its best use for improving the ability of the water works for furnishing fire protection to the community.

In spite of this popular conception of the relative importance of the dual functions of a water system, the fire flow necessary to control properly larger fires in mercantile districts is from five to twenty five times the domestic consumption in the same city. This ratio of required fire flow to domestic consumption is greater for the smaller cities and presents a difficult problem to the municipality which desires to provide a reasonable amount of protection for the safety of life and property from fire.

It is the aim of this paper to point out briefly a few ways in which a water supply system may be materially strengthened at a minimum cost, to furnish more adequate and reliable fire protection.

The cities of Illinois, as well as those in many other states, are classified according to the value of their fire protection as measured by the requirements of an engineering grading schedule prepared by the National Board of Fire Underwriters, from the practical experiences of fire protection engineers, water superintendents and fire chiefs. Under the provisions of this schedule definite quantities of water are prescribed for the adequate protection of cities of different sizes and corresponding standards set for each part of the water works through which these quantities must be passed to reach the fire. The proportion in which these requirements are met is the measure of the quality of the protection afforded by these facilities, and is the means of arriving at the insurance classification of the city.

Each of the several component parts of a water supply system is measured with respect to its adequacy or normal capacity to furnish the domestic consumption, plus the required fire flow. These are compared to determine which is the weakest part, or the limiting feature, of the entire system and the one which should first be improved. A similar analysis is made of the reliability of each part of the system or the capacity remaining after a break has occurred at the most critical location. The distribution system is carefully studied and actual tests are made to ascertain if the size of the main arteries, the secondary feeders and the pipe in the gridiron is sufficient to provide the necessary amount of water to each section of the city. The location, size and condition of hydrants is investigated to determine the ease with which the necessary quantities of water may be

thrown on a fire in any building. Many other parts of the water supply system are thoroughly studied and graded with respect to their ability to fulfill properly their particular function as a fire fighting facility.

In the continual application of this grading schedule to various types of water works, it is surprising to note the frequent recurrence of the same points of weakness. Four suggestions will be briefly outlined for strengthening those points which are of the greatest relative importance. Such improvements will materially increase the adequacy and reliability of the fire protection which can be furnished by a water works to a small municipality.

Greater suction storage capacity is probably the most important of these four considerations. Storage lessens the requirements of those parts of the system, through which its supply has already passed. Thus, greater suction storage for the high lift pumps reduces the necessary well yield, filter capacity and low lift pumping capacity, for maintaining the full required fire flow. The source of supply should be developed to such an extent that the well yield or the minimum stream flow, the low lift pumping capacity and the filter capacity should be as great as economically possible, and at least several times the maximum domestic consumption. Only such quantities as are in excess of the maximum rate of domestic consumption would be available at the hydrant for fire fighting. Since the required fire flow is from five to twenty-five times this domestic rate, it is often prohibitive to provide additional wells or corresponding sources of supply to furnish all of this additional quantity. The grading schedule prescribes that the required fire flow shall be available throughout a ten-hour period, or in very small cities a five-hour period. These requirements, therefore, would be fulfilled, for all portions of the supply works up to the high lift pumps, by a suction storage reservoir, which together with the source of supply would generally be much less expensive than providing deep well pumps and filters of sufficient capacity to carry the greatly increased load necessary properly to control large fires. The investment in the construction of a covered surface reservoir of sufficient capacity for this purpose would enable a great many of the small cities to obtain much more adequate and reliable fire protection.

High lift pumps should have a total capacity in excess of the sum of the domestic consumption and fire flow and should be properly

arranged to pump from the storage reservoir as well as from the normal source of supply. This high lift capacity may likewise be reduced in proportion to the quantity which has passed these pumps and is available from elevated storage at the required fire pressure. Credit can be given for this elevated storage only at the rate at which it can be uniformly depleted over a ten-hour period. Unless the topography of the city makes elevated reservoirs possible, the cost of standpipes and elevated tanks greatly restricts their size so that beyond certain limits additional pumping capacity is cheaper than larger tanks. The capacity of the supply mains must likewise be equal to the requirements, to assure the adequacy of all portions of the water supply system.

Reliability or duplication is the second point for consideration. Pumps and all piping and supply mains should be so duplicated that no single break could cut-off the supply to the built-up portion of the city. All pumping stations, regardless of the size of the city, should have at least two high lift pumps, so that a substantial supply can be furnished while either pump is undergoing necessary repairs. Each pump should have an individual suction from the storage reservoir with connection to the normal source of supply. The discharge header should be so arranged and gated that no single break or repair of a valve would place more than one pump out of service. This would require two gates in the header between each pump. Two supply mains of adequate size should extend into the distribution system and should preferably enter the mercantile district from opposite sides. The pumping station should be entirely of fire resistant construction and all internal hazards should be properly safeguarded in order to minimize the liability of an interruption of service by fire.

Many water works have been found which have two or more pumps and more than one supply main to the distribution system, and yet have a common discharge header, the repair of which would cause a shut down of the entire pumping station and the total interruption of the supply to the city. This is a very important consideration in the design of new plants and often an easy means of materially increasing the reliability of existing supply works.

In the majority of the smaller cities of this state the pumping station is located within a reasonable distance of the closely built portion of the city and in many instances is within a few blocks of the mercantile district. In most of these cities the cost of a second

supply main of adequate size would be more than offset by the substantially increased capacity of these mains under normal conditions, and by avoiding a total interruption of the supply in case of a single break in either line. Where the duplication of the single supply main is not economically feasible, it is often inexpensive to extend a moderate sized feeder from the pumping station to the nearest point of the distribution system. Such a connection will enable a limited quantity to be supplied to all portions of the city while repairs are being made on the principal supply line. These provisions for duplicating each part of the water supply system and for the installation of sufficient valves to prevent any single break from resulting in an interruption of the supply are most important to the health and convenience of the citizens and are even more essential to the safeguarding of life and property against fire.

Our third consideration will be 4-inch mains. It might seem rather unnecessary to dwell upon this familiar subject again, when so much has been said against the installation of this small pipe in fire protection systems. In spite of the acknowledged fact that 4-inch mains are entirely too small for this service, a surprisingly large amount is being installed every year and especially in cities of the size that we are discussing. The most common excuse is the apparent lower cost. A second argument is that portions of the city supplied through this undersized pipe will probably not grow to require quantities in excess of its capacity.

Ample theoretical data and results of innumerable tests are readily available and no attempt will be made here to point out the degree to which the capacity of a fire protection system is limited by the excessive friction loss in 4-inch mains. While the cost of 6-inch pipe is somewhat greater than 4-inch, the cost of laying is nearly the same and the capacity is nearly three times that of four inch. When original installations are entirely of 6-inch mains, with 8-inch feeders at frequent intervals, a material growth of that portion of the city may occur before it will be necessary to provide larger arteries. On the other hand when 4-inch mains are laid because of the existing low consumption in newer districts, it will be necessary to replace a considerable amount with 8-inch or larger pipe as soon as the city has been built up and the increased domestic consumption and fire flow require a materially stronger arterial system. The best engineering and economic solution of that problem is to follow the practice of many progressive cities and use nothing smaller than 6-inch pipe.

Our fourth and last consideration is the location, size and condition of hydrants. The proper spacing of hydrants is determined by the fire flow required for the district being protected. Sufficient hydrants should be located within such a distance of any group of buildings, that this required fire flow may be thrown on the fire with the necessary nozzle pressure. The high friction loss in fire hose limits the efficient lengths of such lines to two or three hundred feet, at the pressures usually available at the hydrant. The small mains often found in smaller cities usually make it impossible to obtain more than two standard hose streams from a single hydrant. Where the fire department is equipped with automobile pumpers, quantities up to the capacity of such pumpers, if available at the hydrant, may be forced through longer lines and be thrown on the fire at a higher nozzle pressure. Under such conditions satisfactory streams will be available within a greater radius of each hydrant. The spacing of hydrants is commonly referred to in terms of the average area served per hydrant. The allowable area served per hydrant varies from 40,000 to 100,000 square feet depending upon the protection required, and usually proportionally with the decreasing size of the city. This area is greater in cities provided with automobile pumpers.

Hydrants should have at least one $4\frac{1}{2}$-inch outlet, two-$2\frac{1}{2}$-inch outlets, a 6-inch barrel, 5-inch foot valve and a 6-inch gated connection to the street main. Hydrants in many of the smaller cities unfortunately fall short of this standard in several respects and materially decrease the adequacy of the water supply system. The installation of hydrants with an undersized barrel and foot valve is gradually being discontinued, but the use of a 4-inch connection to the street main and the omission of valves in this connection is still being followed in numerous small cities. The friction losses in the undersized branch and barrel under a heavy fire flow are excessive and are an unnecessary burden on the other parts of the water works. The cost of individual valves for hydrant branches is more than offset by the ability to repair or replace a hydrant without the necessity of shutting off the supply from several blocks, or where the valve spacing is poor, from a considerable portion of the city. The popularity of the automobile pumper, even in the small cities, makes it good practice to install hydrants having a $4\frac{1}{2}$-inch outlet, even where such a pumper is not actually in service. Where it is not feasible to replace entirely the existing small hydrants, those

near the mercantile and other high value districts should be replaced, or at least removed to outlying sections, and proper sized hydrants with a 4½-inch outlet installed, so that the required large quantities will be available for the control of serious fires.

Hydrants need a fair amount of attention. They should be inspected in the spring and fall of each year, after being used at fires and daily in closely built districts during freezing weather. A large investment in equipment and the efficient operation of all parts of a water works may have been largely in vain if a hydrant has been neglected and fails to perform its function at the critical moment.

In conclusion, we shall name again the four suggestions which have been outlined for strengthening those parts of a water works that have such an important part in providing adequate and reliable fire protection for the small municipality.

1. Substantial suction storage for the high lift pumps is an economical method of providing a supply to meet the demands of a heavy fire flow for a prolonged fire. If the normal capacity of wells, low lift pumps and filters is considerably in excess of the maximum domestic consumption, the necessity for further increasing their capacity several fold may be offset by this storage.

2. The duplication of pumps and supply mains and the proper valving of suction and discharge headers is necessary to assure the reliability of the supply system. Careful arrangement of piping at the pumping station, the construction of the station and the installation of a second supply main to the closely built portions of the city are profitable insurance against the interruption of the supply at the time of a serious fire.

3. Four-inch mains are a detriment to a water system. Installation of this size of pipe is expensive, as large feeder mains must later be installed at frequent intervals to provide sufficient quantities for the protection of the city from disastrous fires.

4. Hydrants should be of sufficient size, frequently spaced and in proper condition. The failure of a hydrant adequately and instantaneously to perform its function defeats the principal purpose for which a water works is constructed and maintained.

DISCUSSION

L. R. Howson:[3] I think this has been a very good presentation of the protection requirements of our water supply systems. I think all of us realise that our systems are deficient in fire protection capacity, but there is another side to it from the standpoint of the privately owned company at least. The privately owned company in a town of 20,000 to 25,000 population finds that 50 per cent of its investment is required for fire fighting purposes and they find it impossible to get more than 10 to 20 per cent back in the way of revenue. It seems to me that is not fair to the water works company. The people wish the benefit of fire protection and I think it should be up to them to pay for it. This is not any argument against fire protection. We must have it.

F. C. Amsbary:[4] The Champaign and Urbana Water Company supplies water to the city of Champaign and Urbana. The value of the plant at the present is about $1,000,000.00. Our revenue is about $150,000. Therefore, according to the speaker's figures we should receive 40 per cent of $150,000, or $60,000 per year, for fire protection. As a matter of fact we are getting about $14,000. This is not a serious matter to the water company where it has state regulation. The state commission fixes the rate of return upon the value of its property, so it matters little to the Company if 10 per cent of its revenue comes from fire hydrant rentals and 90 per cent from its private consumers, but it is not fair to the consumers.

Hydrant rentals should be high enough to cover the cost of the service and should be paid for by taxation. In this way the property that is protected will pay the cost.

We have a number of cases where large property owners require the tenant to pay the water bills. In these cases the tenant is paying a large part of the fire protection on the building in his water bills, because the hydrant rentals are below the cost of producing the service and the rates to private consumers must be high enough to make this up. State commissions recognize this and in many instances have raised the hydrant rental to somewhere near what it should be. No doubt, in time, they will correct this generally.

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[4] Manager, Water Company, Champaign, Ill.

FINANCING WATER MAIN EXTENSIONS[1]

By H. F. Blomquist[2]

The function of a public water works is to furnish various services to the inhabitants of the community in which it operates. The total cost of furnishing these services must be paid by those who receive them. This applies to municipally as well as to privately owned plants. In order to make equitable charges for the different classes of service furnished, such as water for domestic, industrial, fire protection and other public uses, the costs are analyzed into their various elements, and one of the large elements is an overhead, or fixed, expense due to the large investment in the distributing system or pipe lines for bringing the water from the source of supply to the consumer, who may be many miles away.

There are some fundamental differences in the methods that may be used in dealings involving financial matters by municipally and privately owned utilities. This paper will deal with the problem of financing water main extensions by municipally owned plants.

The pipe system may be divided into two main classes, the distributors and the feeder mains. The distributors are the gridiron arrangement of small mains, usually six or eight inch pipes serving the individual fire hydrants and blocks of consumers located along its various lines. The feeder mains are the large pipe lines which conduct water from its source to the various sections of the city to supply the distributors.

The distributors are of value only to the abutting property owners whom they serve with water and to whom they furnish fire protection. In general, an extension of distributors does not add to the usefulness of the water system, except as a means of serving the particular owners who may make connections with them. In other words, they are set apart for the use of a certain group of individuals, and can not be used by any other group. In this respect, they are different from all other parts of a water system. The source of supply,

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Superintendent, Water Works, Cedar Rapids, Iowa.

pumping machinery, purification plant, etc., serve all consumers in common as the needs may be, and improvements or additions to them are equally valuable to all people served by the water system, but this is not so with improvements or additions to the distributors.

The pipe system of a water works represents from one-half to three-fourths of the total investment in the plant, and the small pipes, or distributors, represent the greater portion of the ordinary pipe system. An increase of 100 per cent in the cost of water main construction in a short time, together with an increasing demand for water main extensions in rapidly growing cities, have made the financing of them a major problem, especially in Iowa where there is as yet no authority for financing them by frontage tax, or by special local assessment against the benefited property.

Because of the large investment necessary in distributors, and recognizing the fact that they serve only a certain group of individuals, most of the States have passed statutes, which are upheld by the Courts, that permit municipally owned water works to charge all or a portion of the cost of such extensions to that group. A common practice in those states is to make extensions upon petition of the owners of a majority of the abutting property, and make an annual assessment of usually from 5 to 10 cents per front foot of abutting property for a period of ten years. Another method used is to make direct special assessment of from two-thirds to the total cost of the extension and certify for collection in yearly installments according to the governing laws. The details of the plans are left for each municipality to work out according to its own preferences.

There are several advantages of the special assessment, or frontage tax system, for financing main extensions, among which are the following: Extensions can be made into new and sparsely settled territory without loss to the water department, and people who would otherwise not be able to get the benefit of public water service may have it at a nominal expense, usually much less than any other water supply would cost them. Parties interested in opening new additions can have extensions made without being obliged to guarantee incomes, or pay interest on the investment in a direct way, or to put in water mains at their own cost.

Where special assessments, or frontage tax is not permitted, water departments have resorted to various other methods of dealing with main extensions. Some cities make extensions under contracts with owners of property, by which the owners guarantee an annual

income of a certain percentage of the cost of construction. Others require the land owners to make the extension at their own cost, and when a sufficient number of connections has been made and the revenue equals a certain percentage of the cost, the water departments will take the extension over at construction cost, or valuations to be made according to contract stipulations. These systems have worked fairly well, where ownership of property is vested in one or two parties, but, where lots have been sold to individuals, this arrangement becomes difficult and cumbersome and can rarely be used.

Whether a system of assessment of costs in main extensions is followed by which a portion of the income for water service is derived, or whether some other method is used, the fundamental principle remains that the consumer must eventually pay all costs of the service. There are, however, some decided advantages in one system over another, due to differences in business procedures necessary to provide the required funds. Where no form of assessment or tax for mains is used, all the costs of extensions must come in the form of water service charges. Since the outlay in mains is necessary long before income from them is available, the department must resort to the issuing of bonds or other form of indebtedness for carrying the investment until returns from the same will be sufficient to liquidate them. Frequent issues of bonds are undesirable, are often hard to bring about where popular vote is required, and are more costly than the more direct way of partially paying as you go. On the other hand, when charges are made in one form or another as soon as mains are laid and services available, the financing of extensions becomes greatly simplified.

It must be considered, however, that, if a part of the income is derived from assessment or taxes, the rate for water sold should be correspondingly lower. One is simply a method of dividing the cost of service into two parts, one of which is payable as soon as water service is available, and may be considered as a ready-to-serve charge, and the other part when water is actually used. Courts have sustained ready-to-serve charges in public utilities other than water service, but the principle involved is the same whether it is water, gas or electricity. From the viewpoint of moral justification for such division of charges, it may be stated that the actual difference in sale value of property before and after water is available is generally much more than the amount of assessments or other form of ready-to-serve charges.

Some just objections to making a change from a non-assessment system to the other might be raised on the grounds that owners of property along which future mains are to be laid will be required to pay more for water service in the form of assessments or frontage taxes than owners where mains were laid before who got them without any extra expense. These differences would not be great, however, and are offset to some extent by the older consumers having paid a greater portion, in some instances at least, toward the purchase or building up of the water plant.

In order to simplify the financing of water extensions, and yet to overcome objections to an abrupt change from a method of no assessment or charges to one which involves special assessments or taxes, a proposed law was introduced in the Iowa legislature at the last session, but failed to pass, which provided for assessments against the benefited property in an amount equivalent to the cost of a 6-inch main, but with this difference from the ordinary methods: after a property owner had made connection to the mains and had become a regular consumer, the amount of assessment paid would be refunded to him. This method would simply throw the burden of carrying the investment of water mains in unproductive territory upon the property owner until he would require water service. This principle can be defended on the grounds that the property would be increased in value after water is available fully to offset the expense of carrying the investment. In reality it would be only a ready-to-serve charge for the assurance of being able to have water service, which would be of actual value to the property owner.

Based upon experiences with the problem of financing extensions under both methods, it is the writer's opinion that the ready-to-serve charge or assessment plan for municipal water works meets the requirements much better because it distributes the cost of service more equitably and makes it possible to meet the needs of water service extensions much more readily.

THE USE OF BALANCING RESERVOIRS IN WATER DISTRIBUTING SYSTEMS[1]

By J. E. Phillips[2]

Balancing reservoirs have an everyday name in Los Angeles. We call them kickback tanks, a self-explanatory name. That is just what they are. They fill up with water at night and kick it back out the next day. The principle of their action is not new. Any reservoir placed at the end of a water main farthest from its source of supply acts as a kickback tank.

By its use a main trunk or feeder line supplying a water distributing system along its length is made to work twenty-four hours a day instead of fourteen or fifteen hours as is usually the case when not double headed by reservoirs at each end.

The twenty-four-hour pressure gauge charts of the circular type, clocked on a water main having a reservoir at one end only, almost invariably resemble the cross-section of an egg along its major axis. This is due to the fact that during the hours from 6:00 a.m. to 9:00 p.m. the draft on the main is heavy and the resulting pressure is low, thus forming the small and pointed end of the egg. The larger and more rounded end is formed during the somewhat shorter night period of low consumption and corresponding high pressure in the main.

Let us assume that our trunk line has been designed to care for only a moderate increase in consumption. Then suddenly, as quite frequently happens, and especially so in California cities, it becomes burdened with an abnormal and unexpected demand upon its capacity. Inspection of our pressure charts show that the pointed end of the egg is becoming shorter and flatter and may in extreme cases become concave at the points of peak load. Our patrons begin telephoning, complaining of poor pressure and insisting that we do something to relieve the annoying and unsatisfactory condition.

[1]Presented before the California Section meeting, October 25, 1923.

[2]Assistant Engineer, Bureau of Water Works and Supply, Los Angeles, California.

Our first thought, of course, is to enlarge our trunk line and we at once begin making estimates of costs. The existing main may be a perfectly good cast iron pipe, capable of giving many more years of service. The cost of enlarging or paralleling it may mean the expenditure of thousands or even hundreds of thousands of dollars, depending on its size and length. In water works, the same as in any other business, the financing of enlargements and betterments is an ever present worry. Engineers are constantly faced with the necessity of building their works not more cheaply, but more economically.

With this aim in view we endeavor to find some means of prolonging the usefulness of our trunk line without expending too much of our funds. We again consult our pressure charts, but instead of viewing with alarm the ever increasing flatness of the small end of the egg we discover that there has been practically no change in the large rounded end and we ask ourselves if that nine- or ten-hour period cannot be made one of work instead of rest for our trunk line.

If from our charts, which have been made at several points along the length of the main, we plat hydraulic grade lines for different times of the twenty-four-hour periods, we find that during the periods, 6:00 to 10:00 a.m. and 5:00 to 9:00 p.m., the hydraulic grade lines have a very marked downward slope throughout the entire length of the main, and, in extreme cases, may almost reach as low as the main itself at the end farthest from the reservoir or source of supply. During the night, however, from 9:00 p.m. to 6:00 a.m. the grade lines will extend nearly horizontal from the water surface in the reservoir at the head of the main. In other words we have static pressure. The main is idle. Plenty of water but no place for it to go. Here then is a tentative solution of our problem. Provide a place at the end of the main for the water to go during the night hours so as to be ready for use bright and early the next morning, at the points where it is most needed. Build a reservoir or tank. And, fortunately, it does not have to be large. A small one is usually sufficient.

It is well to remark here, of course, that this solution of our problem is not always possible. The topography of the ground may not permit a tank to be built at the proper elevation. The main may be so extremely small in proportion to its duty as to make its enlargement imperative. In many instances, however, the principle of the kickback reservoir may be utilized very economically.

If, in the further study of our problem, we conclude that conditions are right for the construction of such a reservoir, the next step is to determine the elevation at which to build it and the size. These two factors are a function of each other, and both are dependent upon the capacity of the main and the length of the period during the night when water will be flowing into it. In Los Angeles it is common practice to locate the reservoir at such an elevation as will provide a friction head of about 30 feet in the main.

By taking a series of twenty-four-hour pressure gauge readings on the main, we determine the average length of the period during the night when the main is idle. With a friction loss of 30 feet—or whatever allowable loss we may adopt as practicable—it is a simple problem of hydraulics to compute the amount of water which will flow into the reservoir during the idle period at night. The proper size of reservoir is that which will contain—or slightly more than contain—this amount.

Such a reservoir, properly designed, will alternately fill and empty each twenty-four hours and if hydraulic grade lines are platted under the new conditions, we will find that, instead of sloping uniformly downward as before, they will assume more the position of a suspended cable or catenary, almost as high at the outer end of the main as at the head. Now the main is performing useful work twenty-four hours a day. Complaints of poor pressure and lack of water cease coming in. We breathe easily once more and feel justly proud of our accomplishment.

Speaking briefly of the success of such reservoirs in Los Angeles, I will say that they have not only been money-savers, but have enabled us to keep pace fairly well with the unprecedented growth of the City. Fortunately the topography in our vicinity is adaptable to their use. High towers are unnecessary. For domestic use our practice is to construct riveted steel cylindrical tanks which permits of quick and reasonably cheap construction. An altitude valve or pressure regulator is placed in the main near the tank which automatically shuts off the flow into the tank when filled. The capacity of the tanks is usually from 300,000 to 600,000 gallons. One, however, located at the southerly terminus of a 36-inch main, eight miles in length, on Western Avenue, is 150 feet in diameter, 50 feet high and has a capacity of about seven and one-half million gallons. Its elevation is such as to allow about 80 feet friction head in the main. It is, also, of riveted steel construction and was built

in 1917. This tank has fulfilled its purpose exceedingly well and is still doing so in spite of the increased demands made upon it. Its construction, which cost about $90,000.00, obviated the necessity of duplicating this eight-mile line of 36-inch pipe, the cost of which as you can readily see would have been many times the cost of the tank.

We now have under construction a reservoir on the southerly side of the San Fernando Valley whose function in the irrigation system of the valley is the same as the steel tanks in our domestic system. It will have a capacity when completed of 3100 acre feet and is situated at an elevation of about 100 feet below, and works in conjunction with, the large San Fernando Reservoir on the northerly side of the Valley. This reservoir, known as the Encino Reservoir, was in operation last year, and the results obtained, even in its uncompleted condition, were very gratifying. It will not only take care of the daily fluctuation in service, but is large enough to provide considerable storage for the summer use.

A COST SYSTEM FOR WATER WORKS IN LARGE TOWNS AND SMALL CITIES[1]

By Erle E. Peacock[2]

During the past decade there has been so much interest created in the reduction of costs that a number of states have taken steps to make comparisons easy by requiring uniform accounts for the different water systems. By 1919, water works commissions had established uniform systems in fourteen states. While most of these have been general systems, still they have enabled the managers of the various plants to compare expenditures and remedy deficiencies. These comparisons are so valuable in any attempt to reduce costs that it is surprising that so few states require uniform accounts. It is to be hoped that a cost and not a general accounting system will be required by those states which attempt it in the future. While many general systems give much valuable information, a cost system will produce greater efficiency and more intelligent rates.

Cost systems distinguished from general systems show unit costs. A general accounting system would show all of the different expenses, sources of income and the net profit or loss, but would not attempt to secure the cost of production of each thousand gallons of water and the unit costs of the different processes such as the collection, purification and distribution of the water. A general system would give you the total cost of repairs, but a cost system in addition would distribute this cost over the different processes.

DESCRIPTION OF THE SYSTEM

An attempt will be made to outline for the reader what is considered a desirable cost system. It seems that what is termed a process system would fit a water works. First the plant should be divided into departments or processes and a unit of measure

[1] Presented before the North Carolina Section meeting, November 15, 1923.

[2] Professor of Accounting, University of North Carolina, Chapel Hill, North Carolina.

established. It would appear that the following divisions would prove to be the most logical and natural ones for a small plant: (1) Collection, (2) Purification and Chemical Treatment, (3) Distribution. These may be further subdivided. It is usually desirable to secure the costs of chlorination, which is included as a sub-division under Purification and also Storage and Pumping costs which are included as sub-divisions under Distribution. As in a general accounting system, however, all of the costs of production such as labor, material, fuel, etc., are determined, but they should in addition be prorated over the three divisions or processes, thereby securing the entire cost of each. This would make necessary time tickets and material requisitions so that labor and materials may be correctly charged to those processes which use them. Labor and material would both be used in different amounts by all of the departments. The material should of course be properly stored, and accounted for when purchased and issued, by store record sheets, which would give a perpetual inventory.

DISTRIBUTION OF EXPENSES

The entire cost of the superintendent's office, including his salary, should be secured and prorated over the three processes on a time basis. Repair costs should be summarized in an account and distributed on the basis of the actual work done for each department or process. Depreciation and interest on investment computations are made from the property records of each department and distributed accordingly. All costs in connection with the chlorination of the water, such as labor, depreciation of the meter and equipment and cost of commercial chlorine should be determined and charged to the "Purification and Chemical Treatment Process." All pumping expenses and storage costs should likewise be summarized and charged to the "Distribution Process."

Since purified water is used in cleaning filter plants and water mains, it is necessary that the total cost of the purified water be determined. Therefore, all collection expenses and purification and chemical treatment expenses are transferred into an account called cost of purified water from which can be secured the cost of all water used for cleaning purposes.

Since the cleaning of water mains is done at irregular periods, part of the cost should probably be deferred to other accounting periods. For instance, if the books are closed and costs are secured

every month and the mains are cleaned only once every twenty-four months only $\frac{1}{24}$ of the cost of cleaning should be charged each month to "Distribution." It is necessary, therefore, to carry a "Water Main Cleaning Account" to which is charged all cleaning expenses so that the cleaning expenses prorated to the current month may be transferred to the "Distribution Process Account" and the remainder deferred for charges in future months. All irregular expenses of this kind should be similarly treated.

After all expense accounts have been distributed to the three processes and collection and purification expenses transferred to the Purified Water account the total cost of manufactured water for the month is secured by transferring the "Cost of the Purified Water Account" and "Distribution Process Account" to an account entitled "Cost of Distributed Water" which will include all of the costs except general administrative and selling expenses. The balance of the "Purified Water Account" at this stage should represent the cost of water in the storage basins. Since all water collected and all sold is metered, the amount of gratuitous water and water wasted can be secured. This is charged to the "Distribution Process Account." To the cost per 1000 gallons of distributed water should be added administrative and selling expenses to arrive at the selling price per 1000 gallons. This selling price should furnish funds enough to pay all of the operating expenses, including interest on investment, and administrative and selling expenses. A great many cost accountants are opposed to adding interest on investment to manufacturing cost of goods produced, but in a water works system it seems to be necessary, since water is sold to the consumer on a cost basis and funds must be secured to pay interest on the bonds issued for the purpose of providing plant and equipment. The inclusion of interest on investments in operation costs will also enable managers to compare fairly the different kinds of equipment and thereby use the most efficient.

SPECIAL TRANSACTIONS AND ACCOUNTS

So much has been written relative to the distinction between capital and revenue charges that it hardly seems necessary to mention the fact that all expenditures for and on account of construction work and the installation of equipment, the use of which will extend beyond the current accounting period should be charged to an asset account, and the total cost in the form of depreciation

charges distributed over the life of the property. It is now an established procedure in water works accounting to charge all expenditures for construction work to an account entitled "Construction Work In Progress" and when the work is finished to transfer it to fixed capital accounts.

It is always a difficult matter to determine accurately the cost of operation caused by obsolescence and "wear and tear" of property. The straight line method of depreciation, however, appears to be the best because the per cent loss in value is approximately the same each year and it is the simplest and easiest to apply. Therefore it is the most frequently used. The rates ordinarily found, according to Will. A. Clader in an article in the *Journal of Accountancy*, August, 1919, are:

> Large reservoirs 1 per cent; small reservoirs 2 per cent; cast iron pipe 1 per cent; wrought iron pipe 2 per cent; wood pipe 2 per cent; stand pipe concrete 2 per cent; stand pipe wood 3 per cent; valves 2 per cent; hydrants 2 per cent; meters 4 per cent; pumping equipment 4 per cent; steam engines 4 per cent; boilers 5 per cent; electric generators and motors 4 per cent; filter plant 3 per cent; buildings 2 per cent; laboratory equipment 10 per cent.

It has been brought to my attention that in most cases water is gratuitously furnished to the municipality and its schools, passing the burden of this gratuitous water to the charge consumers. This seems wrong in theory for the schools and the municipal government belong to all of the citizens and there is no reason why any part of their up-keep should be borne by a special class and distributed to them in the ratio of their consumption of water. Then for accounting reasons each department of the city should be kept separate, receiving all charges due and credited with all services, just as if it were an outside concern so that its efficiency may be determined and its management rated. This means that the water works plant should be taxed and the tax charge distributed to the operating divisions and all water furnished the city should be metered and paid for. Eliminating gratuitous and unmetered water would also enable the management to account more closely for water lost in distribution and probably it would be able to curtail this loss to some extent. In this connection it might also be stated that accounts should be kept showing the additional expense to water works for fire-fighting apparatus such as high-powered pumps and like equipment.

COST REPORTS

Illustrative forms of reports that can be prepared from your cost accounts may be found in exhibits A, B and C. Exhibit A is a cost statement for the plant as a whole, showing for each process total costs and the cost per 1000 gallons of water manufactured for the current month, for the same month last year and the total cost to date for the current accounting year compared with the same period last year. This statement is supported by a similar one for each operating process in which the costs are itemized and compared (exhibit B). A third group of statements will be those showing itemized comparisons for the more important expense accounts such as pumping, chlorination, storage and operation management, illustrated by exhibit C.

Budgetary accounting has recently become popular. If estimates are made at the beginning of each accounting period as to future requirements and costs, and budgets for the current period prepared from these estimates, it would probably be better to include in the comparative columns one for the budget estimate rather than "cost to date column for the preceding year," for every manager should attempt to stay within his budget allowance.

It is beyond the scope of this paper to discuss the accounts in detail and the forms necessary for the operation of the system. It might be stated, however, that the usual books of original entry would be required and in addition such forms, as purchase requisitions, material received reports, stock record sheets, material requisitions, time tickets, payrolls, and reports of meter readings. Exhibit D shows a typical set of accounts and by means of numbers indicates the debits and credits for the operating cost accounts.

ADVANTAGES OF A COST SYSTEM

Of course a cost system will entail more records and, therefore, more time and expense. Its advantages should be, therefore, of such a nature as to far outweigh any additional cost. The benefits usually derived from such a system as described in this article are as follows: A good system will enable the manager to have prepared accurate cost reports from which he can secure the necessary information to determine the correct water rate for the consumer, something which is continually in dispute. Furthermore, he will be able to support his rate by accurate cost statements which may be

published, making it easy for him to show why the local rate differs from those of other cities. If costs are excessive he will be able definitely to locate the trouble and probably to remedy it. If costs have increased on account of some uncontrollable force, as a rise in the cost of materials, it will be discovered and he will be able to answer satisfactorily any criticism made of his management. Occasionally new meters and purification, distributing and collection equipment will be invented and offered for sale. In order to determine whether these new processes and new equipment should be installed or not, the question of cost of operation must be considered, for that, of course, is the most important consideration. This comparison of cost of the operation of the new equipment with that of the old is possible only through the use of cost systems. Any misappropriations or waste of materials and supplies will be discovered by a comparison of the perpetual inventory, as shown by the store record sheets, with the physical inventory taken at intervals. A check on the efficiency of labor can also be secured from the time tickets and labor records. Responsibility for improper handling of materials and processes of manufacture can therefore be definitely determined and inefficient employees discharged. A cost system may in addition be used as a basis of standardization. The cost used as a basis in fixing selling prices should be the standard cost of normal production, rather than the abnormal. The most efficient method and economical hours of operation may also be determined through comparative costs. For instance, it might prove to be the most economical to have all of the pumping done at one time or at certain hours of the day. Comparisons for different periods of the costs and income of the whole plant and the sub-divisions such as collection and purification of water can be made which will aid in formulating future policies.

CONCLUSION

Is the system too complicated and burdensome for the ordinary town? It is admitted that for very small plants the system here briefly described would probably be too elaborate, but it probably could be adjusted to fit any plant. The same principles would be involved. In fact in every plant different conditions will be found and no system could be planned which would fit all of them; probably in every case some change would have to be made. Of course, in the smaller plants there would be fewer departments, a smaller number of accounts and longer accounting periods covered by a smaller number of reports.

EXHIBIT A

Chapel Hill Water Works

Cost of Water Statement—June, 1923

	MONTH OF JUNE	COST PER 1000 GALLONS	SAME MONTH LAST YEAR	COST TO DATE	COST LAST YEAR TO DATE
Cost of Collecting Water.....					
Cost of Purifying and Chemically Treating Water.....					
Cost of Distributing Water....					
Franchise Dues.....					
General Administrative and Selling Expenses.....					
Financial Expenses.....					
Total.....					

Total water pumped ———— gallons.

Signed

EXHIBIT B

Chapel Hill Water Works

Cost of Purifying and Chemically Treating Water—June, 1923

	MONTH OF JUNE	COST PER 1000 GALLONS	SAME MONTH LAST YEAR	COST TO DATE	COST LAST YEAR TO DATE
Operating management Expenses					
Cleaning Filter Plants.....					
Labor.....					
Materials and Supplies.....					
Chlorination Treatment.....					
Chemical Treatment.....					
Repairs.....					
Depreciation—Equipment.....					
Depreciation—Building.....					
Interest on Investment.....					
Total.....					

Number of gallons purified ———.

———.

Signed

EXHIBIT C

Chapel Hill Water Works

Expenses of Pumping Water—June, 1923

	MONTH OF JUNE	COST PER 1000 GALLONS	SAME MONTH LAST YEAR	COST TO DATE	COST LAST YEAR TO DATE
Power Charges					
Labor					
Materials					
Repairs					
Depreciation					
Interest on Investment					
Total					

Total water pumped ——— gallons.

_____.

Signed

EXHIBIT D

List of Accounts

A typical list of accounts is shown below for such a system as described in the accompanying article. The accounts are numbered and the kinds of debits and credits for the operating expense accounts are indicated by means of these numbers. For instance, the "Operating Management Expense"—Account No. E-9—is debited with E-5 and E-6, salaries and depreciation of office equipment, respectively, and credited with E-14, E-15 and E-18, showing that this expense is prorated over the "Collecting System Expense," the "Purification and Chemical Treatment Expense" and "Distribution Expense" accounts.

(A) *Assets*

A-1. Cash
A-2. Notes Receivable
A-3. Accts.-Receivable (2)
A-4. Materials and Supplies
A-5. Plant and Equipment (2)
A-6. Construction Work-In-Progress
A-7. Reserves for Depreciation
A-8. Sinking Funds

(L) *Liabilities*

L-1. Notes Payable
L-2. Accts. Payable
L-3. Funded Dept.
L-4. Surplus

(I) *Income Accounts*

I-1. Metered Water Service Revenue
I-2. Hydrant Rentals
I-3. Flat Rate Revenue
I-4. Municipal Revenue.
I-5. Miscellaneous Revenue
I-6. Dividends Receivable
I-7. Interest Income

(E) *Expense Accounts*

E-1. Interest Expense
E-2. General Administrative Exp.
E-3. Accounting and Commercial
E-4. Bad Debts.

E-5. Pay Roll

A-1 (From time tickets)	E-9	E-11
	E-15	E-3
	E-14	E-10
	E-18	E-13
	E-8	
	E-2	

A-4. Materials-and-Supplies

A-1	E-14	E-8
	E-15	E-13
	E-18	

E-6. Depreciation

Res. for Dep. (A-7)	E-9	E-13
	E-14	E-12
	E-15	E-20
	E-18	E-2

E-7. Interest-on-Investment

(S)	E-9	E-13
	E-14	E-12
	E-15	E-20
	E-18	E-2

E-8. Repairs

A-4	E-14	E-13
E-5	E-15	E-20
	E-18	

E-9. Operating M'g'ment. Expenses

E-5	E-14
E-6	E-15
E-7	E-18

E-10. Cleaning Exp. (Filter Plant)

E-5	E-15 (1)
E-16	

E-11. Cleaning Exp. (Water Mains)

E-5 E-16	E-14 E-18

E-12. Storage Expenses

E-6 E-7 E-8	E-18

E-13. Pumping Expenses

E-5 E-6 E-7	E-8 A-4	E-18

E-14. Collection System Expenses

E-5 E-6 E-7 E-8	E-9 E-11 A-4	E-16

Purification and Chemical

E-15. Treatment Expenses

E-5 E-6 E-7 E-8 E-9	E-10 E-20 A-4	E-16

E-16. Cost-of-Purified Water

E-14 E-15	E-10 (1) E-11 E-19

E-17. Cost of Wasted Water

E-19 (1)	E-18

E-18. Distribution Expense

E-5 E-6 E-7 E-8 (1) E-17	E-9 E-11 E-12 E-13 A-4	E-19

E-19. Cost of Distributed Water

E-16 E-18 (1)	E-17 (1) S

E-20. Chlorine Treatment Exp.

E-6 A-1 (Commercial chlorine) E-7 E-8	E-15

Summary of Revenue and Expense

E-1 E-2 E-3 E-4	E-19 L-4	I-1 I-2 I-3 I-4 I-5	I-6 I-7 E-7

(1) It will be noted that the "Cost of Distributed Water" includes "The Cost of Wasted Water," and the "Cost of Wasted Water" includes part of the "Cost of Distributed Water," making it necessary to estimate the "Cost of Wasted Water" to secure the total "Cost of Distributed Water." Any difference between this estimate and actual cost would be transferred to "Profit and Loss." The same condition exists in the "Purified Water" and the "Cost of Cleaning Filter Plant" accounts.

(2) Controlling account for subsidiary ledgers.

WATER MEASURING DEVICES[1]

By Robert L. Daugherty[2]

This paper has not been prepared for the specialist in hydraulic engineering, but rather for the benefit of the greater number who are concerned with the broader and more general aspects of the subject. It has been deemed advisable, therefore, to confine this treatment to a presentation of the different methods of water measurement in such a way as to make clear the circumstances under which each might be used and to point out the advantages, disadvantages and limitations of each device. Obviously, in covering such a broad field it will be impossible to give here sufficient detailed information about every different method as to enable one to apply it successfully. Before using any water measuring device one should make a thorough study of its manipulation in order to avoid errors; but this question is beyond the scope of this paper.

Methods of water measurement may be divided into two broad classes, direct and indirect. The direct are the obvious ones of weighing or measuring volume, and in practice can seldom be used. The commonly used methods are indirect, in that the flow of water is computed as a function of some readily measured quantity. As a rule the devices employed require formulas and coefficients, whose values may be found by experiment. Generally speaking any device, the formula for which can be determined by theory, is to be preferred to one whose formula is purely empirical. But of even greater practical importance is the determination of the coefficient to be used in the formula. Any device for which this coefficient can be computed by theory, or the theoretical value is so near the actual value that one can estimate the latter with but small error, is to be preferred to a device for which the coefficient cannot be even approximately established without calibration. And a device for which this coefficient is approximately constant in value is better than one for which it is variable.

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The most generally accepted method of water measurement is doubtless the weir. Its formula in its simplest form can be derived by a theory founded upon certain assumptions that are known to be untrue. Hence it must be rectified by the introduction of an experimental coefficient. Certain persons in an attempt to express the variations of this coefficient have devised more or less complicated formulas which are largely empirical in their nature. The Bazin weir formula is one ilustration; the Francis formula for a weir with end contractions is another. However, because of the widespread use of weirs and the vast amount of experimental work that has been done upon them, they now offer us a device by which we may attain a fairly high degree of accuracy, provided certain standard proportions are adhered to in their construction and the formula and coefficient are properly chosen to fit the conditions.

If one had a free choice of the type of weir channel that could be used, the highest degree of accuracy and the simplest formula would be obtained by having the weir and the channel of approach of the same width so that there were no end contractions and with the channel so deep that the velocity of approach is inappreciable. In such a case the simple Francis formula may be used and the evidence seems to show that the coefficient 3.33 is constant, except for very small values of the head, throughout the range of head even up to values as high as 5 feet.

If the channel must be shallow and wide, it may be necessary to use a rectangular weir with end contractions, that is the weir opening is not as wide as the channel. End contractions are held to be a source of error and the correction in the formula for them is purely empirical and obviously irrational in form, since the equation would give zero flow, if the head were high enough, and a negative discharge, if the head were still higher. It is clear then that such a weir can be used only within the limits for which the formula was devised.

Third in order of choice would be a weir without end contractions and with a shallow channel so that the velocity of approach is quite appreciable. The correction for velocity is purely empirical and gives rise to various formulas. The writer favors either a modern modification of the original Francis formula or the Bazin formula to fit this case. The latter formula in particular was devised to fit the test results obtained under these conditions.

In addition to the three types of rectangular weirs there are other special forms. First is the trapezoidal weir which would replace the

rectangular weir with end contractons. Its sides slope in such a way as to offset the decrease in the width of the stream as the height of the water increases and thus gives a somewhat simple formula. But it is not necessarily any more accurate because its formula is simpler. In fact it is questionable whether it is as accurate.

For measurement of very small flows and particularly for the measurement of a flow of water which may range from very small to quite appreciable values, a triangular weir offers decided advantages. Some very excellent work on this has been done by James Barr in England. He shows that the channel width should be at least eight times the head on the weir if the flow is to be unaffected. A narrower channel increases the discharge for the same hook gage reading. On the other hand, too shallow a channel decreases the flow.

Since weirs are used not only for the measurement of cold water, but also in power plants for the measurement of hot water, the question naturally arises as to the effect of temperature. A change in temperature of the water alters its density, viscosity, surface tension, and other properties. However a series of tests made at Cornell University by F. G. Switzer and the writer showed that the effect upon the volume discharged could not be detected. This was because some of the changes in the properties tended to increase the flow and others to decrease it and these factors offset each other to such an extent that the net effect was inappreciable.

Within the last few years Clemens Herschel has proposed a new type of weir deviating materially from the standard types previously used. It appears to offer considerable promise, but more experimental work must be done before we could adopt it without calibrating each individual weir built. The advantage of the standard weir is that we may use for our weir coefficients which have been derived by calibrating other weirs of like construction and proportions.

The use of a weir of any type requires an open stream of water in which we can have a fall of a few feet or more. In many cases this is impossible. Other devices for the measurement of an open stream are floats, the current meter, the Pitot tube, and chemical methods of which there are two types.

Floats of various types were extensively used at one time and are still used in special cases to obtain the velocity of a stream. Since water in a given stream may be flowing at widely different velocities at different points in the cross section, it is necessary to

obtain a number of such velocities and multiply each velocity by the area, within which it is assumed to be the average. The summation of all such products is the total stream flow. When used by experienced observers floats are said to give a reasonably high degree of accuracy, but, as they are not very popular at the present time, no further space will here be devoted to them.

The current meter is one of the most popular devices for measuring velocity at a point in an open stream. The calibration of a large number of current meters show that for most of them the relation between meter speed and velocity of the water is a straight line. But the equation of this straight line must be found for each meter by test. It cannot be calculated. Hence one cannot use such a device without having it calibrated. The most generally used current meter in this country is of the cup type. It is rugged and reliable, but suffers from the disadvantage that it registers velocity regardless of direction. What we desire to measure is the velocity at right angles to the cross-sectional area or the component in that dircction, if the true velocity is not really perpendicular to the area. Screw or propeller types of current meters on the other hand tend to measure the component of velocity parallel to their axis of rotation. And for a reverse current in an eddy they run in the opposite direction, thus showing that the velocity is in a negative direction. The cup meter on the other hand always turns in the one direction. This causes it to read too high in a stream where there are marked irregularities and eddies in the flow.

The Pitot tube, in the opinion of the writer, is a very useful and accurate instrument in the hands of an experienced observer. Like the current meter, it measures the velocity at a point. Among its advantages are that its formula can be computed by theory and its coefficient is known to be unity. Hence no calibration is necessary. At this point, however, our attention should be directed to two factors of practical importance. One is that in a stream with a pulsating flow the readings of the tube would naturally vary in proportion to the square of the velocity and the head we should read would be due therefore to the mean of the squares of the velocities and this is greater than the square of the mean velocity, which is what we desire. Hence with pulsating flow the tube reads a little too high. The second factor is the relation of the position of the tube to the direction of the stream. If the flow were steady and if the tube faced exactly up-stream, we should have the same reading, and hence the

same coefficient of unity, whether the tube were sharp pointed, a small hole in a flat plate, or cup shaped. But if the tube is turned through a small angle we find that the sharp pointed or the cup shaped both give practically the same reading as before, while a blunt nosed tube (of which a small orifice in a flat plate would be an extreme type) gives a slightly smaller reading. This is because the former two tend to measure true velocity regardless of direction, while the blunt nosed tube tends to measure the velocity proportional to the component of pressure perpendicular to its orifice. What we desire, as a rule, is the value of $V \cos A$ where V is the true velocity and A is the angle between it and a line normal to the cross-section area of the stream. The blunt nosed tube however tends to measure $V \sqrt{\cos A}$ which is a somewhat larger value. Now, in the actual stream where the flow is more or less turbulent, we have a combination of these two factors, fluctuations in the magnitude of the velocity and variations in its direction. The effect of the two is to give a Pitot tube reading somewhat higher than that corresponding to the true value of $V' \cos A$, where V' is the mean velocity desired. Hence we must introduce a coefficient whose value seems to be very close to 0.98. But it should be noted that the necessity for the coefficient is due to the turbulence of the flow rather than to any inherent defect in the theory or in the instrument itself, and it is largely necessary because we desire the component of the velocity rather than the actual velocity itself. If we desired the actual velocity regardless of direction, we should use either a sharp pointed or a cup shaped point, but the coefficient to give us the axial component of the velocity would be somewhat less than 0.98 for such tubes.[3]

Even in cases where the degree of turbulence is unknown, the amount of error in the use of the Pitot tube is largely measured by the error in judgement involved in choosing a coefficient whose value may range from 0.98 to 1.00.

In the case of an open stream, it is convenient to have some means by which the column of water in the Pitot tube may be drawn up by a partial vacuum to a more convenient location for reading. A second tube should then have a column drawn up in it by the same

[3] A most excellent paper on this subject by Lewis F. Moody, based on investigations by Moody and F. H. Rogers conducted at the Rensselaer Polytechnic Institute, may be found in the Proceedings of the Engineers Society of Western Pennsylvania, vol. 30, no. 4.

vacuum and proportional to the water surface of the stream. The difference between the two gage heights is then the Pitot tube reading.

While the Pitot tube may be used in a flowing stream for fairly low velocities, it may also be used with equal satisfaction for measuring high velocities in jets of water, even as great as two or three hundred per second. The only difference is one of mechanical construction and the type of device for recording the pressure.

It would be well to point out at this time that the Pitot tube may be used also in closed pipes under pressure. But in this case a reading of the pressure in the pipe must be substracted from the Pitot tube reading. In the past there has been much difficulty encountered because of the failure to record this pressure accurately. The best way is to have a piezometer connection in the wall of the pipe and not to attempt to use a static pressure orifice as part of the tube itself. Any pipe projecting within a flowing stream will not give a true measure of the pressure, unless some special construction is used on the end of such a pipe so as to cause the stream lines past the orifice to be the same as if the orifice were in the pipe wall.

In using the Pitot tube in a pipe it is desirable to make two traverses across two diameters at right axes to each other, as the velocity distribution may not be uniform. For subsequent use the work may be shortened by placing the tube at a point where the velocity has been found to be the same as the average velocity or else the tube may be placed in the center of the pipe, where the velocity is a maximum, and the average velocity for the section determined by multiplying the observed value by the proper factor.

Of the chemical methods there are two kinds that differ fundamentally. In one, some color is added to the water and the time that is required for that color to traverse a certain length of path is observed. Obviously this can be applied only to some artificial conduit of uniform cross-section, or a series of such conduits, because velocity must be multiplied by area in order to obtain the rate of discharge. In the case of a natural stream it could be used only if the bed of the stream were fairly uniform for a sufficient distance.

The Ontario Power Company at Niagara Falls at one time used this color method for determining the flow through their penstocks. They constructed a mechanically operated device by which they could discharge about a pound of potassium permanganate crystals into the upper end of the penstock. Desiring to check up the accuracy of this method I tried some potassium permanganate in a

6-foot pipe line 1711 feet long with the water at the lower end flowing over a weir. To my surprise I could see no trace of any color at the lower end. Afterwards I learned that potassium permanganate would be oxidized and rendered colorless, if there were any inorganic matter in the water. Apparently the conditions were different at Niagara Falls.

Later I tried out this chemical method in another place and used a number of different kinds of chemicals. I found that the green colors were best, blues were next, and the reds, purples, and browns were least satisfactory. The difficulty with this last set was that, however vivid the colors might be when made up, they became so pale when considerably diluted that it was hard to tell when they appeared in the water, especially with changing light conditions, as a shadow drifting over the water gave the same effect as these colors. But with the greens especially, there was no difficulty. One could detect the first traces without any question. Of the greens I found that aniline green and fluorescein were both good, but I doubt whether it would be well to use them in water that was to be employed for drinking purposes. I am told that there is a light green color given by a chemical known as S. F. Yellow, which is non-injurious. Indigo disulfonic acid is likewise said to be non-injurious and to give a blue color.

Now as to the accuracy of this method. I desired to see what results I could accomplish with a minimum amount of effort. I took an assistant, therefore, a couple of stop-watches, and the chemicals to a plant where water from a stream entered the intake to a pipe line about 550 feet long, then passed through a turbine, and appeared in the tail race. It would be desirable to have a longer distance than this possibly in order to lengthen the time measured and thus increase the accuracy. Even in this short distance the pipe line was made up of varying sizes ranging from 31 inches in diameter to 72 inches. Thus, I did not consider the situation particularly favorable. Instead of an arrangement to inject the chemical direct into the pipe the color was simply dissolved in about a quart of water and dumped quickly into the intake box. It took 30 seconds for the color to disappear from the time it was poured in. A trace of color would appear in the tail race in 80 seconds, become of maximum intensity, and then fade out in 110 seconds. I decided that the proper time interval to allow was 80 seconds, as that was the time from the injection of the color to the appearance of the first trace and likewise the time that

elapsed between the disappearance of the last of the color at intake and the disappearance of the last in the tail race. From a rating of the water turbine used, from a current meter investigation, from observations of the same flow over the crest of a dam considered as a special weir, and from computations made on the losses of head in the pipe line, it had been decided that the rate of discharge was very close to 45 cubic feet per second. When the computation of the flow from this 80-second interval was completed the result was exactly 45 cubic feet per second. I can recommend this method therefore as being quite reliable and very simple to carry out. A variation of this is to use a salt solution instead of a color and to time its appearance at the lower end of the channel by noting the change in conductivity of the water. However, this is more trouble and does not possess any advantage, except in situations where the color could not be observed, as in a closed pipe for example.

The other chemical method, which has many advantages, the chief of which is that no definite length of uniform channel is required, is to run into the stream a small quantity of a strong salt solution of a known concentration and at a known rate. Samples of the mixture are then taken downstream and analyzed to determine the amount of dilution. Knowing the salt concentration before and after and the rate at which the solution was added, it is easy to compute the flow. This method is simple and cheap and is believed to permit of a high degree of accuracy.

The methods of water measurement previously mentioned are possible only in open stream, except for the Pitot tube and the chemical methods, which may be used with either open streams or closed conduits. We shall now turn to those devices which can be used only in the case of water flowing in closed pipes.

Chief among these is the Venturi meter. It is simple, reliable and accurate. It is only necessary to insure that the connecting piping from the meter to the recording device is neither stopped up with sediment nor partially filled with air. The latter can usually be avoided altogether by properly arranging the piping in the first place. The formula for the Venturi meter can be derived by theory and is so nearly correct that it is only necessary to introduce a coefficient whose value is from 0.980 to 0.985 according to the condition of the meter. While this coefficient is not strictly speaking a constant, its variation is neglible within the usual range of operation.

The usual proportions for a Venturi meter are that the ratio of the throat diameter to the pipe diameter are 1 to 2 or 1 to 3. The smaller the throat diameter in proportion to the pipe, the greater the reading obtained and therefore the more accurate and the more sensitive the instrument becomes. But the loss of head in friction also becomes more pronounced, so that we strive to compromise on these two factors.

The Venturi meter, if installed in a pipe line when the latter is constructed, costs but little and seems nearly ideal for the purpose of giving us the information desired concerning the flow of water through the pipe. Its only disadvantage appears to be that it does add some frictional resistance to the flow of water which may or may not be of much importance. In a specific case of water flowing through a 6-foot pipe line with a velocity of 7 feet per second the insertion of a Venturi meter caused a loss of head of 7.40 feet, which amounted to a friction loss of 166.5 h.p. In this case the power of the turbine supplied by the pipe line was 10,000 h.p. and this friction loss is only a small percentage of the total. This power, however, has a definite money value, whatever its percentage may be. If a Venturi meter be inserted, therefore, in any line from a pumping plant, it will add slightly to the cost of pumping. The problem then becomes one of deciding whether the information obtained is worth the cost. In a gravity line this element drops out, though the meter then would decrease very slightly the capacity of the pipe.

It is somewhat difficult and expensive to install a Venturi meter in a line already constructed and in such cases the orifice meter may be of value, especially for temporary use. This consists of an orifice in a thin plate which may be inserted between the flanges of two adjoining lengths of pipe. If forms a sort of crude Venturi meter, as one measures the drop in pressure due to the increased velocity through the orifice. The difficulty about applying it is that one has to know just where the two pressure connections should be made upstream and downstream and one must use an experimentally determined coefficient. In another type the pressure difference is measured by small orifices in the two sides of the orifice plate itself, thus having some relation to the Pitot tube in principle. This type has the merit that it is entirely self contained and requires no connections made elsewhere. An objection to the permanent use of the orifice meter is the loss of head occasioned by it. For example, in comparison with the Venturi meter previously mentioned, where the

loss of head was 7.40 feet, the orifice meter, under similar circumstances and with the orifice diameter the same as the meter throat diameter, would cause a loss of head of 142 feet. Of course, this means that we should modify the arrangement so that the velocity in the pipe is less or the ratio of orifice diameter to pipe diameter is greater, although at the expense of sensitiveness of reading. Still another method of water measurement is to use an orifice or a nozzle on the end of a pipe where the water may be freely discharged into the air. We have two cases here, also, one where a high velocity jet is discharged under a high pressure and the other where a low velocity jet of considerable size discharges under a low pressure. In both cases formulas and coefficients are known within a reasonable degree of accuracy. There are also two methods of taking the required observation. The usual one is to measure the pressure in the pipe above the orifice. The other is to use a Pitot tube in the center of the jet only and to obtain the discharge from this one reading by the aid of previous calibrations.

It has long been known that when the flow of water through a pipe is stopped within a short interval of time, not necessarily instantaneously, there is a marked rise in pressure, an exaggerated case of which, when the time interval is very small, is known as water hammer. Of course this pressure is only momentary and soon diminishes to normal value. Recently N. R. Gibson has made use of this principle to compute the initial velocity of the water from a measurement of the pressure-time diagram recorded by a special apparatus, as the flow is being stopped. This method appears to yield very accurate results and requires nothing but this photographic recording apparatus connected to the pipe line by a $\frac{1}{4}$ inch tap.

So far all these water measuring devices have been considered from the standpoint of their instantaneous readings, as they would be used by an observer during a test. The current meter, the color and salt solution methods, and the Gibson pressure wave method do not appear to be adapted to any other circumstances. But, in the case of a weir, for example, an observer may make an instantaneous observation with the hook-gage or a recording float mechanism may give us a continuous record of the stream flow. The same is true of the Venturi meter, the orifice and the nozzle. In the case of the Pitot tube, it could be set at a predetermined location and a continuous record made of the pressures obtained. It does not appear to the writer, however, to be especially suitable for that. It might be all right in

clear, clean water, but under ordinary circumstances the lodging of a little sediment or stringy material on its point seriously affects its reading. It seems to be quite satisfactory in the hands of an observer, but of doubtful value as a device to be employed with a continuous recording mechanism.

While there are many other devices for the measurement of water aside from those discussed in this paper, it is believed that these are the ones of most interest. It is apparent that the choice of the device to be used is determined very largely by the circumstances in each case.

OPERATION RECORDS FOR SMALL WATERWORKS[1]

By Earle L. Waterman[2]

During the past four years the writer has had occasion for one purpose or another to inquire for the operating records at a number of small waterworks plants in Iowa. Generally the result of these inquiries has been to find that there are few such records. The value of operating records in large waterworks plants is accepted without question and the forms in which such records are kept are becoming more standardized each year. Is there any factor which depends on the size of a water works plant which determines whether or not operating records are worth keeping? If we can agree that such records are worth while for the small, as well as the large, waterworks then it seems to the writer that such a group of waterworks men as are gathered here for the meeting of the Iowa Section of the Association should take the initiative in trying to obtain more and better operation records at the small water plants. It is the purpose of this paper to point out the value of operation records to discuss the existing situation, to suggest methods of improvement and, if possible, to start a discussion on a subject which appears to deserve the attention of an association of waterworks men.

It is rather difficult to define the term small waterworks. In a paper on "Modern Pumps for Small Waterworks," which was published in the *Journal of the New England Waterworks Association* in March, 1920, Mr. C. W. Fulton includes under Small Waterworks those plants which have a daily capacity of 3,000,000 gallons or less. Such a classification may perhaps serve the purpose of this discussion, although the writer feels that in the Iowa plants whose capacity is 500,000 gallons or more per day some effort is generally made to keep records of operation. While in most cases these records can be improved—particularly in those plants which under our classification may be called small waterworks—it is in the smaller plants,

[1]Presented before the Iowa Section meeting, October 24, 1923.

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whose capacity is less than 500,000 gallons per day, that the greatest improvement can be made. Definite data concerning the number of these plants are not available, but from such information as could be obtained the writer estimates that out of 500 plants in Iowa 490 would be classed as small waterworks and, of this number, 464 have a capacity of less than 500,000 gallons per day.

The records which ought to be kept at a waterworks plant should show all facts relating to the operation of the plant. In a broad sense the keeping of such records may be called bookkeeping or accounting. However, properly kept records will not only show costs of operation, but will also show pertinent facts in regard to the quality of the product and point to reasons for variations in quality. A successful waterworks plant is one which supplies water which is satisfactory from every standpoint, to its customers, and also gives good service at at minimum cost. The facts in regard to the operation of such a plant should be kept in permanent form so that they may be always available. We profit by experience—the operating records should be a complete record of experience obtained in operating a waterworks plant. When it is too late we often find that the memory of the plant superintendent is not as trustworthy as a written record.

The operating records should include an inventory of all plant equipment, a record of the amount of water furnished to the distribution system each day, amount of power used per day, pressure maintained, occurrence of fires, labor costs, plans of the distribution system, all changes in the distribution system, installation and removal of meters, meter testing, quantities of chemicals used for treatment, data concerning treatment, and the results of the examination of all samples of water which are analyzed to determine the quality. It is probable that other items should be included. This is not a complete list by any means and is offered only for the purpose of suggesting what the writer has in mind when he uses the term operating records. It will be noted that, aside from labor costs, which are a factor of operating costs, the financial items are not included. The reason for this omission is that such records do not always come under the province of the superintendent of waterworks. It is not our purpose to discuss the important matter of the determination of water sales rates.

The operating records should be of the greatest value to the plant operator. Such records ought to enable him to operate the

waterworks plant in the most efficient manner. The efficiency of the plant units as well as the efficiency of the plant as a whole can be determined. If the plant is not operated continuously, a study of the operating records should show at what times and for how long a period the plant can be most economically run. It should show him the variations in quantity of water available at the source of supply and the variation in ordinary demand, together with the effect of fire demand. The record would show the effect of the seasons both on the quantity and quality of water and on the plant and distribution system. Some one will say that the old operator knows these things. In a general way this is true, but such information cannot be as reliable as the written record, and the new man coming on to the job does not inherit his predecessor's memory! Properly kept operating records should be invaluable to the man who makes them.

The making out of reports to the State Board of Health and to the State Public Utilities Commission will be very much easier for the man who keeps a daily record of his plant operation. These state supervisory authorities are not unjust in their requests for information. The object of such supervision is to protect the health and the pocket book of the citizens of the state. Speaking only from the standpoint of the water utilities we must admit that the primary function of such public utilities is first to furnish a safe and satisfactory water, and, second, to supply such water to the consumer at a reasonable cost. Then the question arises as to who is to determine whether or not these requirements are being fulfilled? The consumer knows whether or not the water is satisfactory, but he is a poor judge of its safety and has very little knowledge on which to base an opinion as to the cost. Safety and cost are matters to be determined by specialists and for the small water works the services of qualified experts in such matters is not feasible from an economic standpoint. When such advisory service is furnished by the state, plant operators should realize its value and by hearty coöperation obtain maximum benefits from it. Operating records make such coöperation possible and not a burden.

Most small towns and cities have the laudable ambition to grow and history shows that a majority of them do increase in size. Growth means enlargement, extension, and improvement of the waterworks plant. When these matters come up for consideration the first inquiry made, by the engineer who is to make the plans,

is for the past records of plant operation. On the basis of such records he is able to forecast more accurately the probable future demands and plan for a plant that will furnish a safe, satisfactory and economical water supply. The degree of success which he attains will be largely measured by the data which he finds available. Operating records are valuable in planning improvements to the waterworks plant.

At a majority of the waterworks plants in Iowa where some form of purification process is used operating records are being kept. The Chief of the Water Laboratory of the State Board of Health has been making a very commendable effort during the past two years to encourage the keeping of such records. If the plant operator keeps only a duplicate of the weekly reports which are required by the State Board of Health he will at least have a fair start on operating records.

Perhaps the most serious obstacles in the way of getting operating records at small waterworks are, first, lack of proper equipment and record forms, and second, the fact that in many cases the operation of the waterworks plant is only a part of the duties of the man who is city marshal and superintendent of streets. Probably not more than one-fourth of his time is devoted to the waterworks. With so many things to claim his attention it is not surprising that he does not keep records at the waterworks.

If such records are to be obtained, it is essential that simple forms be planned and further that some equipment for measuring pressures and recording the amount of water furnished by the plant be installed. A recording pressure gage will be very helpful to the operator. Venturi meters or master flow meters may be used to determine the daily flow. If it is not possible to install a meter, a stroke counter on the pumps at pumping plants may be used. Where the plant is not run continuously the time of starting and stopping should be recorded. In the smaller plants the furnishing of a diary or log in which daily notes can be made may serve to encourage the operator to make some records.

Remarkable progress in waterworks operation has been made during the last twenty-five years. Much of this advance in knowledge has been due to the work of the American Waterworks Association and the benefits have been reaped by men whose time is entirely devoted to waterworks. Should not this work be extended to help the operators of smaller plants? There are hundreds of

them in Iowa. A committee on operation records for small waterworks would find a large field in which to work and, in the writer's opinion, a field in which assistance would be greatly appreciated. Work of this kind ought to result in interesting small waterworks operators in the work of this Association. Up to this time these men have not been interested. Has not the time come when some constructive effort should be made to obtain their interest and coöperation?

SENSITIVE DETECTION OF SUSPENDED MATTER AND A PROPOSED STANDARD OF CLARITY IN FILTERED WATER

By John R. Baylis[1]

A few years ago the author attended a performance in one of the local theaters in which one of our famous "bathing beauties" gave an exhibition of her diving stunts. The tank used had a glass side in order that she might be observed while under the water. Greatly to his surprise and to the disappointment of the "bathing beauty," she could scarcely be detected while under the water, unless very close to the glass side. Water that had passed the filter plant and was recorded as having zero turbidity fell far short of its classification. Not long afterwards another shock was received when informed by the manager of one of the swimming pools that it was necessary for them to construct and maintain a filter plant to clarify the city water for bathing purposes. Many industries were still operating their old private filters that were constructed before the Montebello Filters were put in operation. This gave added proof that the clarity of our water was not meeting the demands of the consumer in many instances. When they complained of cloudy water we would point with pride to the column in our daily report showing zero turbidity practically all the time. The consumer usually went away with the feeling that it might look all right on paper, but the water was not satisfactory. Zero turbidity meant nothing to him when he could not see clearly the bottom of his white bathtub. In the course of time we began to feel that possibly our bottle sample of water about 4 inches in diameter was not giving an accurate means of detecting suspended matter.

A submarine light was installed in the bottom of one of the clear water reservoirs at the Montebello Filters in 1918, where it would be under about 8 feet of water. When the light was first turned on we were undecided whether it should be left in the place installed

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or hid in some secluded spot where only the superintendent and the chemist might observe the filtered water. This was the beginning of a great improvement in the clarity of Baltimore's water, which with the use of other sensitive devices has made it one of the clearest filtered waters supplied any city. It was found that no one device entirely solved the problem of detecting suspended matter. It may be extremely fine particles caused from imperfect coagulation, or fairly large size coagulated particles passing the filter beds, or both. If it is insufficient coagulation the chemicals should be changed to the proper amounts, and if it is suspended matter passing the filter beds the ones passing such matter should receive attention. Armstrong[2] has shown that loss-of-head cannot be used as a criterion for washing filters, especially in the winter months. With good coagulation the proper operation of filters is largely the prevention of the passage of floc. A light about 8 feet under the water with 6 or 8 feet of water around it detects turbidity, but does not tell the amount or cause. No sampling or observation device on the market offered the degree of sensitiveness desired. Consequently experiments were started in 1918 to perfect a device for installation on each filter that would sensitively detect the floc passing. After several unsuccessful efforts a device was finally perfected. A description of it has already been published.[3]

The use of some such device as this cannot be too strongly commended for the proper operation of rapid sand filters. It has met our greatest expectations in detecting floc passing the filter beds. For detecting fine colloidal particles due to poor coagulation the light under the water gives a fairly good indication, but another device is used in the laboratory for its estimation.

PRACTICALLY NO EFFORT HAS BEEN MADE TO DETERMINE TURBIDITY OF FILTERED WATER

Most of the early efforts to perfect devices for examining filtered water have been to make them show clear water. Some of the older operators possibly did not want sensitive detection of suspended matter. Had they been privileged to select devices of various degrees of sensitiveness they would have almost invariably selected

[2] Armstrong, Jas. W.: Loss of head as a criterion for washing filters. Engineering News-Record, vol. 87, December 29, 1921.

[3] Baylis, John R.: Sensitive detection of suspended matter. Public Works, January 7, 1922.

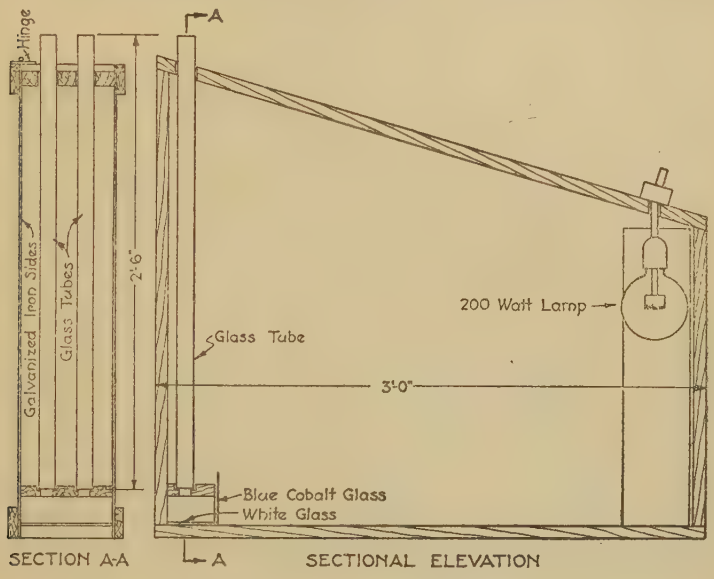
the least sensitive. To have offered turbidimeters as herein described years ago would have met with about the same reception as did Edison's device for hastening roll-calls in Congress. Something to make the water look clear when it was not would have had a ready sale in many filter plants a few years ago. It is a fact that filter operators have shown very little interest in the degree of clarity of their filter effluents as long as the turbidity is not noticeable in an ordinary half-pint glass of water.

A little turbidity may have no great sanitary significance, and a filter operator may be justified in supplying water with a turbidity of 0.5 p.p. m. or more in some instances, but he should have some means of telling just what it is. If we cannot tell whether water has a turbidity of 1 or 0.1, how are we going to ascertain the proper amount of chemicals to use and when to wash filters? We are very careful to determine that the raw water turbidity is 35 and not 34 or 36, yet we are making very little effort to tell if the filtered water is 0.5 or 0.9. At the point where greatest accuracy is needed there is the least. We prefer to look at a bottle of water that appears to be fairly clear and call it zero turbidity without making more accurate tests.

Realizing that such "rule of thumb" methods must soon disappear in water purification, the author has devoted considerable time to the perfection of devices other than the ones mentioned for laboratory uses. When the observation light that is under about 8 feet of water shows a slight cloudiness, there should be some means of determining the turbidity other than a guess. When a slight amount of floc is observed in the floc detectors on the operating tables, there should be some means of telling whether it is a floc turbidity of 0.02 or whether it is 0.10. For experimental work turbidity differences become very important. *Most of the experimental work on chemical treatment of water for clarification loses much of its value because accurate turbidity determinations have not been made on the water after filtration. It is no wonder workers differ so widely in their results when working with water of approximately the same character. Until there is greater accuracy and more uniform methods of procedure progress is going to be slow.*

NEW TURBIDIMETERS

Prior to 1923 the best method that could be found for making turbidity comparisons was to compare in 75 cm. tubes similar to the one used with the Jackson candle turbidimeter, using dilutions of the raw water for standards. This gave fairly good results, but the color interfered somewhat with its accuracy and it was necessary to have daylight for comparisons. In the early part of 1923



TURBIDIMETER FOR SENSITIVE
DETECTION OF SUSPENDED MATTER

FIG. 1

an accurate and sensitive turbidimeter was perfected that not only tells turbidities as low as 0.1, but is not affected by colors below 5. Colors between 5 and 15 interfere very little. Figure 1 shows a plan of the turbidimeter.

Two glass tubes the same size and length of the 75 cm. tubes used with the Jackson turbidimeter are used for comparisons. One for the sample and the other for the solution of known turbidity. They should be as near the same clearness of glass as is possible. A box as shown in the plan is used for covering the light and holding the tubes and glass plates. The box shown was the cheapest possible to construct. So valuable an instrument should

have a neater appearance, but this does not affect its accuracy. The purpose is to get a very bright light from the side on the particles in suspension so as to illuminate them, and a perfectly blue light underneath the tubes. It is desirable to cut out as much of the white light rays as is possible underneath the tubes. The best plan possible shows a white plate underneath and a blue so-called cobalt glass on the side. This will cause all the light to be blue. With clear water containing no matter in suspension the bottom shows blue, but when there is suspended matter the white light reflected from the particles in suspension cuts out some of the blue rays. Most of the blue is cut out with a turbidity of 1, but turbidity differences may be detected when it is as high as 2.0. A turbidity of 0.1 is easily detected, and differences of 0.1 are readily noticeable when the turbidity is below 1.

In a recent article the author advised using standards made from the raw water before treatment. This was possibly the best means of determining the turbidity at that time, but it seems that we might now go back to Fuller's earth as being the better, due to the standards being more permanent than they would be if made with some natural waters. If we are dealing with turbidity alone, it is likely there will be no great advantage in using the natural turbidity. Two or 3 grams of Fuller's earth are added to about 1 liter of water, thoroughly agitated, and allowed to stand twenty-four hours. Part of the supernatant liquid is poured off and tested for turbidity with the Jackson candle turbidimeter. If it is less than 25 more earth is added and the procedure repeated until a turbidity of at least 25 is obtained. Portions of this solution are diluted to the desired turbidity. The standards and the stock solution are not permanent, so it is necessary to test frequently the stock solution and prepare new standards. This was done every week at first, but the standards change very little in two or three weeks.

This device gives a measure of the total suspended matter, which may be partly colloidal and partly floc passing the filters. It is desirable that a determination of each be made. With turbidities below 1 the floc may be of much greater importance than the colloidal matter. The colloidal matter will not settle out in the distribution mains, but will remain evenly dispersed in the solution. If not readily noticeable it will cause very few complaints. The floc is quite different, and water should be as free of it as possible. If very small quantities are present, it will settle in the pipes when the velocity is slow and may gradually accumulate to considerable amounts in places. An increase in the flow picks it up, and may

cause the water to become very turbid for a short while in these localities. Possibly all are familiar with the cloudy water in the

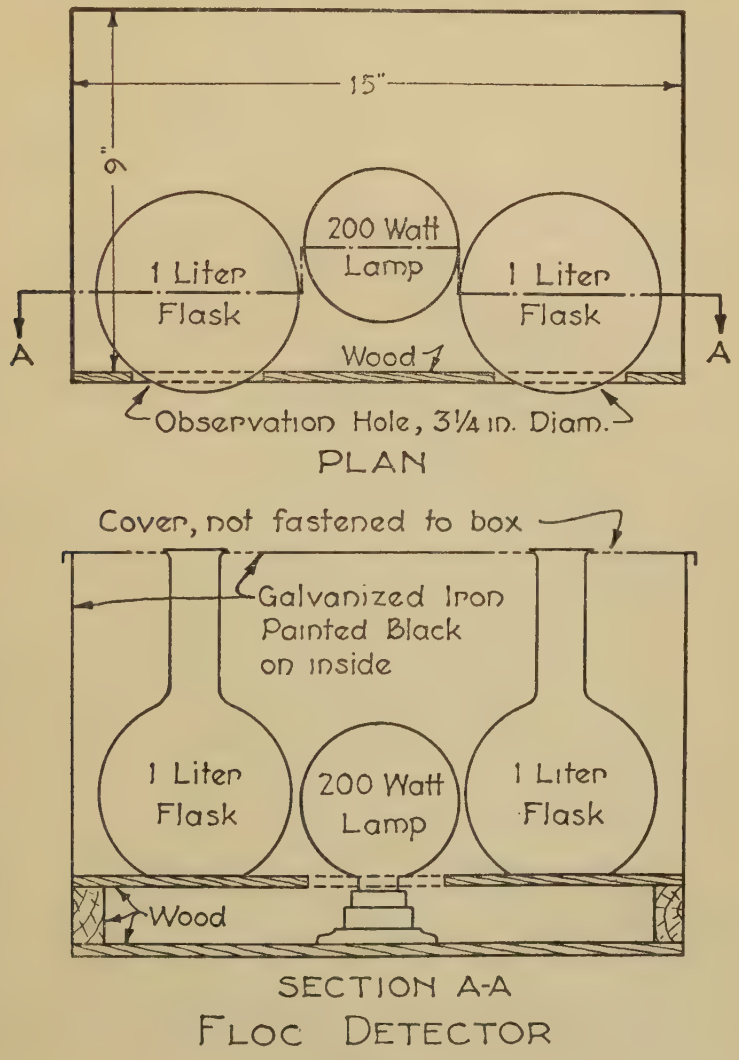


FIG. 2

vicinity of a fire or broken main. Corrosion of service pipes in many supplies greatly aids in forming these "pockets" of muddy water and may be the sole cause in some supplies. There are many in-

stances, however, where the cause is floc passing the filter beds. *No rapid sand filter plant filtering coagulated water is entirely free from floc passing the beds all or most of the time.* A few operators may wish to challenge this statement, but the use of devices herein described will prove its correctness.

It has been most difficult to devise a quantitative estimation of floc. The particles are readily observed with the floc detectors on the operating tables, but they do not tell quantity in proportion to the water. If we depend on such estimations as none, a little, or considerable, it will be very difficult to compare work. One observer might call considerable a little and vice versa. The method adopted, which seems to be giving satisfaction, is to take a turbidity of 20, prepared by diluting higher turbidities to this amount with clear tap water or adding a little turbidity if below, and adding 1.5 g.p.g. alum. A good coagulation is obtained by stirring fifteen minutes. Then a flask is filled about one-half full with this solution and agitated vigorously for one-half minute. This constitutes the stock solution, which may be kept for a month or more. Each time it is used it should be thoroughly agitated. One cubic centimeter of the solution diluted to 1 liter with clear distilled water will form a turbidity that is 1/1000 of the original. To give a name it might be called "floc turbidity," and 1 cc. per liter is a floc turbidity of 0.02. This is a more or less arbitrary scale, but gives a basis for comparison. Once we have determined the point on this scale beyond which it is not desirable to exceed it can be used with nearly as great accuracy as though it were a volumetric determination. Floc turbidity standards are prepared to cover the desired ranges, varying 0.02 below 0.10 turbidity and 0.05 above that amount. These standards are not permanent and should be changed every few weeks. For comparison, a device as shown in figure 2 is used. This is a modification of the floc detectors used on the operating tables. The sample to be tested is thoroughly agitated for one-half minute, given a whirling motion in the flask, and put into the floc detector. The approximate turbidity is determined by eye, then compared with standards treated in the same manner as the sample before placing in the floc detector. With one or two trials the turbidity may be determined accurately.

LABORATORY PROCEDURE FOR DETERMINING SUSPENDED MATTER IN FILTERED WATER

Daily tests are now made in the laboratory of the Montebello Filters on a composite filtered water sample. This is a mixture of samples taken every two hours. Frequently other tests are made to aid in adjusting chemicals. Three tests are made on this sample; one in the laboratory turbidimeter to determine the total turbidity, one in the floc detector to determine the floc turbidity, and another in the laboratory turbidimeter to determine the colloidal turbidity. One of the glass tubes of the laboratory turbidimeter shown in figure 1 is filled with water from the composite sample and allowed to stand at least five minutes for the air bubbles to rise to the surface. An approximate turbidity determination is made with the eye. The other tube is filled with a standard, the preparation of which has been described, allowed to stand at least 5 minutes, and a comparison made. One or two comparisons are usually all that are necessary for an accurate determination. The results are recorded to the nearest 0.1 turbidity if below 1, and to the nearest 0.2 if above. Turbidities above 2 may be diluted with distilled water for comparison. This gives the total turbidity. The floc turbidity is determined as previously described, and recorded to the nearest 0.02 turbidity if below 0.10, and to the nearest 0.05 if above this amount. Colloidal turbidity is determined by filtering a portion of the composite sample through filter paper that has been thoroughly washed by filtering at least 2 liters of clear water, and using the same procedure as with the total turbidity.

A PROPOSED STANDARD OF CLARITY FOR FILTERED WATER

The present standard of clarity for filtered water, if judged by filter plant records, is a turbidity of zero. The author does not offer one "quite so rigid." To propose standards without a mass of evidence to substantiate the reasons may be treading on dangerous ground. Reliance in this case has been placed on what we have found to give satisfaction with our water. Due to overloaded and other conditions we have not produced an effluent at all times entirely satisfactory from the standpoint of clarity. This has enabled us to get a fairly good idea of the limits beyond which we should not exceed.

The colloidal turbidity should not at any time exceed 0.5, and the composite sample should not exceed 0.2. The floc turbidity for the combined effluent should not at any time exceed 0.04, and the composite sample should not exceed 0.01.

This may be setting up a very rigid standard for filtered water, as very few plants are producing such an effluent. The almost universal use of chlorine has, in the opinion of many, obviated the necessity of operating filters at their greatest efficiency. The author does not concur in this opinion. It has been his experience that the water consumers are willing to pay for the best possible. The record of failures to ratify bond issues for improvement to water supplies are few where the issues are for an improvement in the quality of the water. The value of satisfaction is recognized by nearly every one, and the sooner our water works officials realize, with our present standard of living, that quality within certain bounds is preferable to economy the sooner will the desired progress be made. Failure of our officials to keep abreast of new developments is now doing more to retard progress than protests of increased costs from the consumers.

A STUDY OF THE EFFICIENCY OF THE IMPROVED WATER PURIFICATION PLANT AT WILMINGTON, N. C.[1]

By George D. Norcom[2]

During the past few years there has been a great deal of activity by the various cities of North Carolina in building water purification plants and improving the plants already existing. No doubt this movement has met with opposition in some quarters, since there are always those who are satisfied with conditions be they ever so unsatisfactory. It occurs to the writer that, if some of the improved plants could show in simple terms the benefits derived from the improvements, the opposition would be effectively silenced. It is the object of this paper to describe briefly the changes which have been made in the Wilmington plant, to compare the efficiency of the new plant with the old and to discuss the relative costs of operation.

Since 1882 the raw water for Wilmington has been taken from the Northeast branch Cape Fear River, a highly colored and rather polluted stream. At first the water was used without treatment, but since 1906 it has been subjected to rapid sand filtration and of late to chlorination. Before alterations were made last year the plant consisted of the following units: Three sedimentation basins with a combined capacity of 1.53 million gallons, so designed to as give a high velocity of passage (0.86 feet per minute), 12 filters of 0.5 million gallon each per twenty-four hours, chlorine apparatus, clear well, standpipe and storage reservoir. The purified water was pumped directly to the mains, the plant being operated twenty-four hours per day. Alum and lime solutions were fed through orifice boxes directly to the raw water pump suction, there being no mixing chamber. Chlorine was applied to the clear well by means of a duplicate installation of Wallace and Tiernan chlorinators. The

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Sanitary Engineer, County Board of Health, Wilmington, N. C.

filter sand was of three different types ranging in effective size from 0.36 to 0.62 mm. Air and water wash was used.

The principal objections to the old system were as follows: The raw water was highly colored and at times turbid, so that it required constant supervision at all times. In spite of this, unsightly water gained access to the mains occasionally. The water was polluted with fresh sewage from the city, since it was possible for sewage to reach the intake within thirty minutes after its discharge into the river. Judged from its B. coli content the water was too highly polluted for a safe load on the purification plant. The water was subject to pollution from sea water so that at times it became absolutely unpalatable and caused considerable damage to boiler tubes and hot water systems. The filter plant was of peculiar design representing three different periods of building. There was no mixing chamber. The pipe connections between the basins were small and in some cases inadequate. The basins were designed to give a high velocity of flow. Eight of the 12 filters were provided with Earl controllers which were not satisfactory. The use of air and water wash resulted in clogging of the underdrains and imperfect washing. The sand in some of the units was too coarse.

During the past year a new raw water supply has been secured and the plant has been completely overhauled. Two miles of twenty-four-inch C. I. pipe including a 600-foot river crossing were required to secure water from the Northwest Branch of the Cape Fear River at a point on the river nearly 5 miles above Wilmington. The new supply is a turbid stream having a mineral content fully as low as the Northeast Branch and practically free from sewage pollution. The only town of any size on the watershed is Fayetteville about 80 miles above the intake. Moreover, the chance of sea water contamination of the new supply is remote. A new low lift pumping station is located on the Northwest Branch where two electrically operated centrifugal pumps of 4 million gallons per day capacity each deliver water to the sedimentation basins. A recording Venturi meter is placed in the filter house.

A mixing chamber with over and under baffles has been provided which is designed to give twenty minutes retention at a velocity of 0.8 feet per second when operating at a rate of 6 million gallons daily. The effluent from the mixing chamber is discharged through a diffusing wall into the main sedimentation basin which has a capacity of 800,000 gallons. By allowing the water to enter at the side of this

basin and flow across, the velocity has been reduced to 0.35 feet per minute without altering the retention period of 3 hours. The two small basins which are of 360,000 gallons capacity each, have not been changed, although the piping between the basins has been arranged to allow flexibility of operation.

The old solution feed apparatus for chemicals has been replaced by three Roberts dry feeders. Two of the machines feed alum and lime to the first basin, while the third is used for adding lime to the basin effluent to restore alkalinity.

All filters have been equipped with Simplex controllers and resanded with a local sand of effective size 0.49 mm. and uniformity coefficient of 1.33. This sand is not as fine as had been specified, but it appears to be giving satisfactory results. High velocity wash has been substituted for air and water, wash water being supplied from an elevated tank of 50,000 gallon capacity.

This is a brief statement of the improvements made. A full description has been written by C. W. Smedberg, Sanitary Engineer, and will be found in Public Works for September, 1923. The engineers on this work were the Carolina Engineering Company of Wilmington, N. C., and the contractors were Tucker and Laxton of Charlotte, N. C.

The new supply was put into service on April 20, 1923. It had been studied by Prof. E. B. Phelps, Mr. Geo. F. Catlett and the writer, and it had been unanimously recommended as superior to the old supply both as regards quality and ease of treatment. The results of numerous analyses indicate that, chemically, the waters are practically identical. Physically they are entirely opposite, the one being highly colored with little turbidity and the other highly turbid with little color. In this difference lay the opportunity for increased economy, laboratory experiments indicating that the turbid water would require only about one-half as much alum as the colored. While the advantage of the mixing chamber and low velocity of basin flow was scarcely apparent on the colored water, it was very marked on the turbid water. With the colored water coagulation appears to be instantaneous and a good floc appears at once if optimum conditions are realized, but with the turbid water containing colloidal clay the benefit of the stirring action is apparent to the eye, it being possible to follow the progressive formation of the floc and subsequent clarification effected as the water passes through the mixing chamber. An important point in this con-

nection is that the optimum for good coagulation is pH 4.4 with the colored water and pH 5.5 with the turbid water, while the pH range for good coagulation is much narrower with the former than with the latter. When the coagulated water passes through the diffusing wall most of the floc settles quickly as can be demonstrated when the basin is drained for cleaning. By utilizing various basin combinations it is possible to secure retention periods from two and four-fifths hours to twelve hours at the rate of 3 million gallons daily. The most advantageous retention period for the warm months seems to be about eight hours.

The dry feeders for chemicals have proved greatly superior to the old solution feed. Stratification of alum solutions and clogging of lime orifices have been obviated. It is now possible to maintain a uniform feed and to regulate the dose according to the flow as indicated by the Venturi meter.

The high velocity wash has already saved us a considerable amount of wash water and it is believed that it will overcome many of the difficulties formerly experienced from clogged underdrains and uneven application of wash water. The Simplex controllers have given complete satisfaction. The removal of bacteria by the filters equipped with the new sand has been uniformly efficient.

In table 1 will be found the average results for total bacteria and B. coli for five months of 1923, the corresponding five months of 1922 and for the three year period, 1920–1922. In table 2 the corresponding percentage removals are shown. It will be seen that under average conditions the results are good both for the old and new supplies. In general the percentage removals are better for the old plant, which is readily explained by the fact that the old raw water was much more highly polluted than the new. With high pollution the figures for percentage removal will be high. This efficiency was only attained by the application of large doses of alum. In tables of this kind it is not possible to show how, in October, 1921, the B. coli index on the treated water rose to 1.9 per 100 cc. as a result of a heavy load of pollution. At about the same time the chloride content of the water rose to nearly 4000 parts per million. These were among the factors which forced Wilmington to seek a new supply. Referring to the tables it will be observed that the disinfected water had a higher count than the filtered water during the five-month period for 1922. This was due to after growths following chlorination, a condition which has not been troublesome since the new supply was put into service.

TABLE 1

	BACTERIA PER CUBIC CENTIMETER AGAR 37°C.	B. COLI INDEX PER 100 CC.
1922 (five months)		
Raw water	1,587	3,282
Basin effluent	121	
Filter effluent	46	27.7
Disinfected effluent	65	0.46
1923 (five months)		
Raw water	655	160
Basin effluent	126	
Filter effluent	65	0.77
Disinfected effluent	8	0.014
1920–1922 (three years)		
Raw water	1,806	2,166
Basin effluent	150	
Filter effluent	43	37
Disinfected effluent	23	0.39

TABLE 2

Percentage removals

	BACTERIA PER CUBIC CENTIMETER	INDEX PER 100 CC.
1922 (five months)		
By sedimentation	92.5	99.2
By filtration	62.0	
By disinfection	−41.4	98.3
Total	96	99.9
1923 (five months)		
By sedimentation	80.8	99.5
By filtration	48.4	
By disinfection	87.7	98.2
Total	98.8	99.9
1920–1922 (three years)		
By sedimentation	91.7	98.3
By filtration	71.4	
By disinfection	46.5	98.9
Total	98.7	99.9

In table 3 the average figures for five months of 1922 and 1923 respectively have been substituted in Streeter's formula, $E = cR^n$.

TABLE 3

Streeter's formula, $E = cR^n$

For 37° agar count: $c = 0.23$, $n = 0.55$.
For index per 100 cc: $c = 0.29$, $n = 0.30$.

	RAW WATER		FINAL EFFLUENT			
			Total bacteria at 37°C.		Index	
	Total bacteria at 37°C.	B. coli index	Found	Calculated	Found	Calculated
1922 (five months)	1,587	3,282	65	13	0.46	3.0
1923 (five months)	655	160	8	8	0.014	1.3

TABLE 4

Materials, labor and costs

	THREE-YEAR AVERAGE (1920–1922)	COST PER MILLION GALLONS	FIVE MONTHS AVERAGE (1923, MAY TO SEPTEMBER)	COST PER MILLION GALLONS
Filter plant				
Water filtered average, million gallons daily	3.230		3.183	
Wash water gallons per million gallons	27,000	$1.67	14,900	$0.76
Alum, pounds per million gallons	407	7.77	218	3.75
Lime, pounds per million gallons	113	0.82	37	0.28
Chlorine, pounds per million gallons	5.55	0.42	3.84	0.27
Coal, pounds per million gallons	2,340	8.49	133	0.43
Power, kilo-watt hour per million gallons			495	9.15
Labor, per million gallons		9.06		8.19
Total cost of purification, per million gallons		$28.23		$22.83
Pressure pumping				
Coal, per million gallons		$16.98		$0.85
Power, kilo-watt hour per million gallons				18.32
Labor, per million gallons		14.25		9.32
Total, per million gallons		$59.46		$51.32

This formula was derived from the examination of a large amount of data on filter plant performance and it indicates what may reason-

ably be expected from a well operated filter plant. It will be seen that for 1922 the bacterial removal does not reach Streeter's figure, but that the B. coli index exceeds it. The results for 1923 check the formula for total bacteria, but greatly exceed it in B. coli removal.

From the above considerations it appears that the improved plant is fully up to the standard that may be expected of a well operated filter plant as regards bacterial removal. From the point of view of physical appearance the turbidity has been reduced from an average of 69 to 0. With the old colored water the color removal was from an average of 151 to an average of 13.

Table 4 shows the relative amounts of material used to purify the two waters and the cost of each item. Separate figures are given for the cost of pressure pumping. The totals represent the actual cost of purifying the water and of delivering it to the mains. On chemicals the saving effected is roughly as follows, in percentage: alum, 46; lime, 70; chlorine, 30. The saving in wash water is nearly 45 per cent. The cost of pumping is about the same for the low lift pumps, but there is a saving of almost $3.00 per million gallon on the pressure pumping due to reduction of personnel. The total saving on the filter plant amounts to $5.40 per million gallon or about $18.00 per day. The saving effected on the entire process is $8.14 per million gallons, $26 per day or about $9500 per annum. Add to this the saving due to discontinuing the operation of a sewage pumping station designed to prevent pollution of the old raw water, which amounts to nearly $5000 per year, and we have saved enough to pay the interest on the bonds issued for the improvements.

In closing, the writer would like to request all the superintendents to compile their records for filter plant efficiency and cost of operation so that when we meet next year we can compare these figures. In this way we might arrive at a standard of comparison which would be of mutual advantage to operators and to the cities they represent.

YIELD OF WELLS[1]

G. C. Habermeyer[2]

The State Water Survey Division has secured considerable information in regard to the yield of wells in this state. The yield, within certain limits, depends upon the depth to which the water level is lowered so information in regard to water levels is secured when possible. In the short time available I shall attempt to demonstrate the various pieces of apparatus used to measure depths to water as they are described.

When actual tests cannot be made information is secured in regard to the capacity of pumps, the depths at which pump cylinders are placed, the lengths of air lines for air lifts, and starting and operating pressures of air lifts. The capacity of a pump in a well gives the maximum possible yield of the well as operated, the depth of the pump cylinder with some allowance for suction pipe below the cylinder gives the maximum depth to which the water level can be lowered, and the length of air lines and air pressures when using air lifts give some information in regard to water levels.

It is usually possible to secure information in regard to yield by measuring the discharge in a reservoir, by noting meter readings where meters are installed, or by counting pump strokes.

A small yield may indicate little water available or it may indicate poor condition of pumping equipment. A lowering of the yield may be due to a partial exhaustion of the supply, to cave-in in the well, to deterioration of casing, or to deposits on and in the walls of the well due to reactions of waters. Fine sand drawn against a screen often greatly reduces the yield of a well into sand and gravel. Many of the waters in sand and gravel contain considerable iron and when the water level is drawn down below the screen air is allowed to gain access and deposit may be formed which may clog the screen and the material close to the screen. It is probable that considerable iron deposits are also formed in some deep wells in rock. At

[1] Presented before the Illinois Section meeting, March 20, 1924.

[2] Engineer State Water Survey Division, Urbana, Ill.

Mendota wells into rock are cleaned of such deposits regularly twice a year by forcing a scraper to the bottom.

The reaction of waters is referred to in a report made in 1910 to the city of Rockford by Alvord, Maury and Mead, in bulletins of the State Geological Survey Division, and by well drillers. This may be caused by a lowering of the water level or by a mixing of waters. In some wells the water level is lowered a considerable distance below the level at which it stands when not pumping. This gives a corresponding reduction of pressure on the water which may account for the release of gases and with the release of gases, especially carbon dioxide, a reaction in the water. Many wells in rock in this state penetrate several water bearing strata. Analyses of waters from various strata show considerable difference in the mineral content and the waters from the various strata rise to various elevations. For example, in drilling a well when a depth of 100 feet is reached water may flow in and rise to 50 feet below the ground surface and when a depth of 1000 feet is reached another water bearing stratum may be entered and water may then stand at 150 feet below the ground surface. Water from the stratum at a depth of 100 feet, unless cased out, will then be flowing into and downward in the well and may react with water in the stratum at the bottom of the well causing deposits on and in the walls of the well.

When possible it is very desirable in testing the yield of a well to determine the water level, not only in the well pumped, but in other wells or test holes in the vicinity in order to determine not only the yield of the well but the amount of water available and thus also to secure information in regard to the condition of the well pumped.

Various methods of measuring to water level have been referred to at previous meetings. I remember particularly discussions by Mr. Burdick, Mr. Enger and Mr. Beauchemin.

A simple arrangement is to use a wood float preferably weighted at the bottom so it will be held vertical, reducing the tendency of wedging in the well.

The depth can be determined readily by lowering a weight and noting when it strikes the water, if other noises nearby are not too great.

Mr. Beauchemin has referred to lowering a rubber hose. When the lower end reaches water and is lowered an increase of pressure may be noted at the upper end of the hose.

A good method for regular installation is to place a small pipe of known length into the well and attach an air pump and a gauge. When pumping at a slow rate so that friction is negligible the pressure when the gauge becomes stationary is the pressure required to force water out of the pipe. Deducting this from the length of the pipe gives the depth to water. At least one pump company is leaving apparatus practically the same as we have here as equipment with some of their installations. The University of Illinois has an air pressure line connected to the pipe and the gauge so hand pumping is not necessary and the pressure can be read at any time.

A magneto, which as used is practically a small dynamo turned by hand, may be used. Current is carried from one terminal on the magneto through an insulated wire which is lowered in the well. The end of the wire is protected to prevent it from touching the well casing. When the water level is struck current flows through the insulated wire, through the water to the well casing, and up through the casing or the ground to a connection which must be made from the casing or the ground back to the other binding post of the magneto. When the circuit is completed the bell of the magneto rings.

When traveling from city to city we must limit the weight carried as much as possible. Recently we have generally used an electric lighting circuit when it is available. An insulated wire carrying the current is run to a lamp and an insulated wire connected to the other terminal of the lamp is lowered into the well. When the lower end of the wire, which is protected from contact with the well casing, touches water the lamp is lighted. Electric wiring in many cities including Urbana is not all that it should be. Two wires are connected to each lamp socket and as installed it is a guess which one is carrying the current to the lamp. In order to save time we use an extension cord with one wire fastened to one lamp socket and the other wire fastened to another lamp socket. A bulb is first placed in one socket and the other terminal of that socket is connected to the ground, if the lamp does not light it is connected to the wrong wire and is put over into the other socket. Insulated wire is then connected to the second terminal of the proper socket and lowered into the well until the water level is reached as determined by the lighting of the lamp. Sufficient weight is placed on the lower end of the wire to hold it straight. The Kewanee Boiler Company has a very good apparatus of this type with the wire on a reel and the lamp socket on the side of the reel.

Mr. Bushnell and Mr. Marquardt of the Champaign-Urbana Water Company lower a wire through a small pipe placed in the well which keeps the wire straight and prevents contact with casings.

Travelling from place to place, with rough treatment of insulated wire when measuring, unwinding, winding, scraping over couplings and edges of well casing there is danger of partially destroying the insulation and allowing the current to flow from the wire at such place to the well casing or pipe flange, especially after the line is wetted. We carry at all times a protected float which can be used when there is doubt of the insulation of our wire, when there is no lighting circuit available, or where water is flowing downward in a well from a stratum above water level and might close the circuit with the electric apparatus that has been demonstrated. With this apparatus a low voltage current from one or two dry cells is connected in circuit with a buzzer or bell and two wires which are lowered into the well. The wires end in a tube in which small holes are drilled near the top and the bottom to allow air and water to flow in or out. A float held vertical with an electric conductor at the top (in this case made from a ten cent piece) is placed in the tube. When water is reached the float rises and the conductor at the top touches the terminals of the two wires, thus closing the circuit, and the buzzer operates. Very good contact must be secured to ring a bell or operate a buzzer. There is little danger from poor insulation and to save weight we use one wire insulated and the other one uninsulated. There is danger of too much insulation due to slight corrosion of the points and these must be kept bright. Mr. Siebert, Superintendent at Riverside, has used an apparatus similar to this for many years.

When we travel in auto we sometimes carry this apparatus which has the wires on a reel. The shaft is in two pieces insulated from each other with one wire connected to one piece of the shaft and the other the wire connected to the other piece of the shaft. The buzzer and dry cells are packed compactly in the box. This is arranged to use with the two wires and the float, but may be used with a lighting circuit using the insulated wire only.

DISCUSSION

M. M. Symons:[3] We operate wells with the water bearing strata approximately 90 feet below the surface. We drill from 50 to 60 feet below this stratum in the shale for submergence. We have an Indiana air lift, and to determine the draw-down or level of the water, the air pipe that connects to the pump has a tee on it and on that we have an ordinary steam gauge graduated to 1 pound graduations. We tried to regulate the air with an ordinary globe valve, which was not successful, so we put in stop cocks and by making a mark on the stop cocks, we could get a more satisfactory control. It was a simple matter to shut off the globe valve and to get the draw-down, and take measurements for the water. After being in operation for thirty-six hours, there is a draw-down of from 30 to 35 feet. In some of the wells it takes 80 pounds air pressure to start them, and then from 43 to 47 pounds will operate them nicely. We find that about 60 to 65 per cent submergence is the most economical point, but with us it was not economy; by increasing the air we can increase the output of the wells.

When we clean our screens, we shut off the discharge and turn in the air pressure at 100 pounds, which will come up sometimes 8 to 10 feet from the well; a great many times right up around the casing. This blows the sand back from the screen. Then when the well is released, the sand rushes in through the screens, cleaning off the accumulated iron on the screens, leaving the coarse gravel outside the screens. By doing this every few days, we find the well gives a better flow, and does not clog the screens. When blowing this well, we sometimes get shale and accumulated iron, as this shale comes from the lower strata.

[3] Chief Engineer, Interstate Water Company, Danville, Ill.

OBJECTIVE, POLICY AND PROCEDURE OF THE NORTH CAROLINA STATE BOARD OF HEALTH IN WATER SUPPLY[1]

By H. E. Miller[2]

As a result of the vision and foresight of our distinguished past president, president, president elect and certain other progressive engineers, waterworks men and public health officials, certain laws were enacted by the General Assembly, creating for the State of North Carolina what are commonly known as the State Water Supply Laws.

The first of these was the law requiring quarterly inspection of water sheds of public water supplies secured from streams and waterways. This law was enacted in 1899.

Next came the law requiring monthly analysis by the State Laboratory of Hygiene of samples of water from public water supplies, enacted in 1905.

Then in 1911 the law was enacted requiring State Board of Health approval of plans for proposed water works and sewerage improvements. This law specifies also certain other duties of municipality and state respectively in connection with water supply protection.

The foregoing laws have not been materially added to or amended since the enaction of the law of 1911.

It is a fact worthy of mention that the North Carolina water supply laws not only antedate similar laws in most other states, but that, even with the rapid growth and development of the state, they seem quite adequate for the control of the major water supply and sewerage problems of today.

The State Board of Health is designated by these laws as the State agency responsible for their administration. Since all regulatory statutes must define duties and responsibilities for the governing agency as well as for the governed, there are imposed upon the

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Director, Bureau of Sanitary Engineering and Inspection, North Carolina State Board of Health.

State Board of Health certain specific duties and responsibilities with regard to public water supply. It is the purpose of this discussion, therefore, to set forth in the broadest sense an interpretation of our responsibility in this connection, and to indicate wherein you may profit by taking advantage of the facilities which the State, through the State Board of Health, has placed at your disposal. In the June issue of the Health Bulletin the legal wording of the statutes is translated into current English, and the respective duties of State and municipality are defined and explained. Time will therefore not be consumed here in repetition. It is suggested, however, that all those whose duties are in any way connected with public water supply management secure copies of the June Bulletin.

There can be only one purpose for all health legislation and one objective of any state public health agency, which is, necessarily, to protect the public health. Inasmuch as the fundamental principle of public health practice is based upon the recognition and correction of potential dangers to health, no half way measures or partial protection can be accepted or condoned if protection of the public health is to be effected.

The application of safe standards of protection to the various classes of supplies will now be considered.

GROUND WATER SUPPLIES

Given a source of supply located as remotely as possible from developed sections of the community or sections that are likely to develop with good, natural and artificial drainage, with satisfactory details of pump pit drainage, and attachment of pumps to casing, and with rigid control of sanitary conditions around the source, in short with all visible evidences or possibilities of pollution removed, the supply should be safe. Even occasional samples, however, from such a source showing the presence of B. coli on monthly analysis indicates such a supply to be potentially dangerous. If the cause of the presence of B. coli cannot be located and remedied, the continued use of the supply constitutes a menace to health and the abandonment of the source of supply is imperative. In the meantime chlorine sterilization of all water used from such source is an essential safeguard.

SURFACE WATER SUPPLIES

Unfiltered. This class of supply is found only in the mountain sections. The watersheds are uninhabited and trespass of any kind is prohibited by State regulations and patrol. The raw water of this class of supply is normally pure, but there always remains the possibility of trespass which constitutes a potential danger.

Filtered. This class of supply is found principally in the central and eastern section of the State. The raw water of this class of supply is normally impure on account of the character of the watersheds, on most of which farming, timber, cutting, etc., are extensively practiced. In some instances the waterway used as the source of supply receives the sewage of one or more municipalities upstream. This type of supply therefore requires effective filtration to remove impurities. If the filter plant is properly constructed, it can and should remove all pathogenic or disease germs at all times, as indicated by B. coli, provided the operation of the plant is conducted under sufficient rigidity of check and control. It is believed that this measure of efficiency is a reasonable and essential requirement of filtration.

At this point the raw water of the normally pure surface supply, used without filtration, and the filter effluent of the normally impure supply requiring filtration are on a par value of safety.

Both supplies are at this point, however, potentially unsafe, the first because of possible trespass upon the watershed, and the second because of possible decreased plant efficiency, due to the failure of certain items of plant equipment to function to the maximum degree of efficiency, or some failure on the part of the operator. A second line of defense or measure for insuring uniformly safe quality of water is therefore imperative to offset the potential element of danger. This is accomplished by some form of sterilization or disinfection, such as chlorine, either liquid gas or bleach, ultra violet ray, ozone, etc. Since chlorination is the simplest and cheapest process of sterilization, it has been most extensively practiced. Both the liquid gas and bleach process of sterilization are being used satisfactorily.

In the case of any supply the fact that sterilization is being practiced is no valid reason or excuse for relinquishing the utmost diligence in protection of the watershed or maintenance of *maximum* efficiency of filtration, because chlorination would then become a

purification or primary process of treatment, constituting the one and only line of defense, and the element of potential danger would still exist.

In striving to attain a safe standard of water supply protection throughout the State, the responsible State agency must recognize the necessity of definitely established policies, by means of which it is proposed that the attainment of the objective shall be accomplished.

The government of our State is founded upon the principles of democracy and local self government. Consequently, it is neither the purpose of the State laws nor the policy of the State Board of Health to supersede local governmental functions or to interfere in any way with this principle.

Accordingly, the protection of water supply, is primarily a local responsibility. It is believed that the interests of the Stateat large can be served to the best advantage by coöperation to the greatest possible extent with the local officials on whose shoulders the responsibility directly rests.

Having established a policy of coöperation, it becomes necessary to determine the plan of work or method of procedure from which the greatest benefit in water supply protection will be derived. It is believed that "service" is the answer to this question. Through the State Board of Health and its engineering staff, therefore, the State is prepared to assist the municipality in matters pertaining to water supply protection. Some of the items of service that are thus made available are advice or helping to secure information, assisting to secure necessary water supply improvements, helping you to improve your system of plant operation, or assistance in any other capacity that we may be able to serve without encroaching upon the field of the practicing engineer.

To summarize briefly, the State Board of Health has a definite objective which is "safe water supplies," a well defined policy which is "coöperation," and a standard method of procedure which is "service."

ACCURATE CONTROL OF AN OLD FILTER PLANT[1]

By Earle G. McConnell[2]

In presenting this paper I shall endeavor to describe, in a non-technical way, the advantages gained at Charlotte through the accurate control of its old filter plant. It should be remembered, however, that the various means devised meet the conditions at the Charlotte plant and may or may not be applicable to other old plants. As our new plant was scheduled to be in operation the first of the year, it was not advisable to go to any appreciable expense for control apparatus.

The city of Charlotte obtains its water supply from the Catawba river. The river pumping station is located 11¼ miles from the city. It contains two electrically driven Morris centrifugal pumps, each having a capacity of 3500 gallons per minute or a combined capacity of 10,000,000 gallons per day.

The river pumps discharge into a settling basin which is located 5 miles from the city. This basin has a capacity of 60,000,000 gallons and allows a plain sedimentation period of approximately seven days. The outlet crib has openings at three depths, thus allowing the water to be drawn from near the surface regardless of the water level in the basin.

From the settling basin the water flows by gravity to the filter plant, which is located 1¼ miles from the center of the city, and enters the coagulating basin under a head of 140 feet. The coagulating basin is 100 by 200 by 10 feet deep and has a capacity of 1,500,000 gallons. It is divided into two equal compartments, allowing the plant to operate one compartment when it becomes necessary to clean the basin. Each compartment contains three around-the-end baffles placed on 25-foot centers and the end of each baffle is 18 feet from the opposite side of the basin. This gives the water a lineal traveling distance of about 850 feet. Since the maximum flow of water through the basin is estimated to be at the rate of 8,000,000

[1] Presented before the North Carolina Section Meeting, November 15, 1923.

[2] Superintendent of Filtration, Charlotte, N. C.

gallons per day it allows a minimum retention period of four and one-half hours. However, with the average consumption 4,700,000 gallons per day, the average retention period is seven and one-half hours.

Alum and lime are used as coagulants. Solutions of each enter the raw water at a uniform rate, the dosage being controlled by addition of the required amount of each chemical to its solution tank at fifteen-minute intervals. Unslaked lime in barrels is purchased in 60-barrel lots and is slaked, a barrel at a time, just before use. Seventeen per cent lump filter alum is used and is purchased in car load lots. The alum and lime solutions enter the raw water line 50 and 75 feet respectively from the entrance to the coagulating basin. The raw water with its doses enters at the bottom of the basin,through a 16-inch 45-degree bend turned up, under 60 pounds pressure, causing the water to roll and tumble and giving an excellent mix between the water and the chemicals.

It may be easily seen that, with no raw water meter, and with such an inadequate method of applying coagulants, the control of dosages and the flow of raw water was a problem. Since there is only one solution tank for each chemical, with no means of controlling the flow of the solutions the feeding of solutions of constant strength through orifices was out of the question. It has been the custom to add enough alum and lime to the solutions tanks to make the water "look right," with no regard for the amount of raw water being treated. Of course, the necessary apparatus for proper control could have been installed, but since our new plant will be ready the first of the year and the present plant has been operated for the past ten years under these conditions, it was decided that, if a satisfactory means of control could be devised, any new installations for such a short period would be inadvisable.

Since there was no meter there had to be some means of controlling the flow of raw water in order to know definitely the amount that was being treated. The raw water is fed into the coagulating basin through a 6-inch gate valve. After careful observation of the maximum and minimum amounts of water required for the distribution system together with the flexibility of the plant it was found that we could operate satisfactorily by using three settings on the 6-inch valve. To explain in detail—this valve opens completely on fourteen full turns. By using three settings of fourteen, eight, and five turns we can have the water enter the basin at one of three definite rates of flow.

In order to get an accurate control of the chemical doses two sets of sheet metal cans were obtained, one set for alum, the other for lime. Each set has 8 cans which are plainly numbered from 1 to 8 and range in size from 4 to 10 inches square. The sizes are calculated so that any series of three cans will take care of the fourteen, eight, and five turns on the raw water valve. For instance, alum cans 6, 7, and 8 will take care of fourteen, eight and five turns on the 6-inch valve when the turbidity of the raw water is 100 p.p.m. When the turbidity changes to 200 p.p.m. then cans 5, 6 and 7 are required. The can in use is filled level with its chemical and added to the solution tank at fifteen-minute intervals. A small blackboard was put up at the chemical house and day by day the numbers of the cans required, which vary according to the character of the water, are placed opposite the fourteen, eight, and five turns. It has been found that turbidity is the most uniform determining factor of the amount of coagulant required for Catawba river water, so a chart has been made showing the cans required for various turbidities. The men who feed the chemicals have been taught to measure turbidity with the United States Geological Survey turbidity rod and then refer to the chart for the numbers of the cans that correspond to the turbidity measured. In the absence of the plant operator they may readily adjust the doses should a change in the water occur. Under ordinary conditions this method works admirably. However, at first what might be termed the human equation of the men was overlooked. It was a difficult, if not impossible, task to get ordinary labor that could be depended upon to get the chemical charges in on time. They would invariably be a few minutes early or late and often during the night shift would miss charges altogether, the result being that the water would be underdosed and a turbid filter effluent would result. They would then attempt to correct their negligence by adding extra charges resulting in an overdose and a waste of chemicals. This problem was solved by getting an ordinary watchman's clock and requiring the men to punch the clock each time they charged. The plant now has an undeniable record of every charge of chemicals for months back and the men absolutely cannot neglect their work without being detected. It might be of interest to add that the night shift man was discharged within a week after the clock was installed. The saving in chemicals effected through regularity of feed more than paid for the clock the first month. The result of its use has greatly increased the quality of the filter effluent.

The outlet from the coagulating basin to the filters was formerly a 16–inch cross at the bottom of the basin. This pulled the water from the bottom and gave the basin a very low efficiency and caused an excessive amount of wash water for the filters. A brick well was built around this outlet and its height brought up to 30 inches of the average level of water in the basin. The result was a 25 per cent increase in the efficiency of the basin and a reduction of about 25 per cent in wash water for the filters.

We have 10 wooden tub gravity filters with mechanical stirrers. Each has a filtering surface of 177 square feet making a total filtering surface of 1770 square feet. Upon examination it was found that about 25 per cent of the sand surface was covered with foreign material such as cinders, wood chips and small pieces of coal. This caused not only a very irregular, but a reduced filtering surface. Each filter was thoroughly scraped and cleaned and all are now giving very satisfactory results. With old type filters such as those at Charlotte one of the greatest problems is to get a good wash. They have no rewash, filtered waste outlet, loss of head gauges, or rate controllers. Washing the filters was invariably followed by a turbid effluent until a sufficient mat was formed on the surface of the sand to make a good filtering medium. It was observed that under normal conditions the peak of the load occurs around noon and gradually decreases until about 6:00 a.m., when it begins to pick up again. Due to lack of flexibility of the plant, anywhere from 2 to 10 filters are required during the twenty-four-hour day. The 10 filters were divided into two sets of 5 each, the first set being washed at 4:00 p.m. and the second set at 4:00 a.m. This is based on a twenty-four wash which has been found to be ample under normal conditions. After the first set is washed in the afternoon, they are allowed to stand idle full of coagulated water until the next morning when the second set is washed. Those needed are then placed in service and the second set cleaned and allowed to stand until such time as they are needed for service during the day. By this method it may be seen that we have all our filters clean for the day run and by standing idle for a few hours the filter tends to settle and a slight mat forms on the sand surface, so that, when they are put into service they give a much brighter effluent than if they were put into service immediately after washing. In fact it is difficult to detect in the total filter effluent when the clean filters are placed in service.

We now come to the important question of what has been the result of these rather crude methods of attempting to place this old type filter plant under accurate control. First of all, the quality of water produced has exceeded all expectations, both as to physical and bacteriological standards. The filter effluent is clear and bright at all times and with but two exceptions during the past four months has passed the Treasury standard for a sanitary water before being chlorinated. The saving of coagulants is shown in the following table:

MONTH	AVERAGE TURBIDITY	ALUM	LIME
	p.p.m.	*gr./gal.*	*gr./gal.*
June	275	3.0	1.1
July	250	1.0	0.3
August	575	0.9	0.18
September	525	0.8	0.08
October	210	0.7	0.0
November (twelve days)	90	0.4	0.0

A conservative estimate on the saving in chemicals is $5000 per year. There will also be other economies in the general operation of the plant such as wash water, coal, oil, and so on. Experiments are now being conducted to ascertain if sulphate of iron can be used on Catawba river water. If these experiments are successful and sulphate of iron substituted for sulphate of alumina, there will be a further saving in the cost of coagulant. While these experiments are not far enough advanced to come to any definite conclusions, indications are that iron can be used on this water.

Though these various mechanical methods and devices have contributed to the control of this old type plant, any success that has been attained has been due to the fact that the plant has been operated under strict laboratory control and the results of laboratory tests have been *interpreted* and applied directly to the operation of the plant. It is not meant by this that a lot of unusual highly technical analyses are made. Only the ordinary physical and chemical tests for turbidity, color, alkalinity, carbon dioxide, hardness, and hydrogen-ion concentration are made and the bacteriological tests for total bacteria and B. coli. In coagulation the optimum point can only be determined by laboratory tests and can be held at this point only through the strict interpretation of laboratory tests, the result being that the water is being properly treated at a minimum expense for coagulant.

Some plants are still attempting to operate without any form of laboratory control whatever. Such operation should be prohibited, for an improperly operated water plant is a great menace to public health. The reason for this apparent indifference on the part of the public lies in the fact that they cannot see or comprehend the hidden danger that lies in a clear sparkling glass of polluted water. The writer firmly believes that, if they did understand the ever present menace of having their water supply coming from a plant that is operated by guess work, we would have more rigid requirements governing such operation.

There are other plants that make all the necessary chemical and bacteriological tests, but do so mainly as a matter of routine and record. There are extreme cases in municipally owned plants where a good laboratory and technician has been acquired as a screen behind which to hide an inefficient political henchman in a soft job. Other plants have the work done through their city board of health. Such tests, of course, are valuable as a matter of record and for ascertaining the quality of water being furnished the consumers at any particular time, but, unless these tests are interpreted, they are of little value in the successful and economical operation of the plant, The technique of making these tests is very simple. In fact any intelligent person can soon learn to make them accurately, but only a man who understands the basic principles of water purification can make the proper interpretation of these tests. In other words, a plant should, by all means, have a laboratory, but not a laboratory alone. It should have a trained man capable of making and interpreting all the necessary tests and occupying such position in the plant that he can apply these interpretations and direct the operation of the plant accordingly.

Plants that are operated without rigid control invariably tend to rely upon chlorination as the means of producing a safe water. They attempt to use emergency measures in the routine operation of the plant. There can be no doubt as to the value of chlorination under proper control. It has probably done more to insure sanitary water supplies than any other one process ever developed in water purification. But, by chlorinating a distinctly turbid water, it can be made safe from a sanitary standpoint without any further treatment whatever. The practice of allowing the water to pass through the coagulating basins and filters with little thought as to its quality, feeling secure in the knowledge that a dose of chlorine at the end of the process will make the water safe for consumption is, in the writer's opinion,

placing water purification upon a false foundation. If the proper chemical dosage is applied and the basins and filters are operated efficiently, the filter effluent should show no turbidity and should be sanitary. It should then be followed with a dose of chlorine merely as a precautionary measure.

The ideal plant from the operating standpoint has a good laboratory and has a competent and trained man in charge of its operation. A plant so operated is the best health insurance a community can carry. At the same time this important public utility is being operated at its maximum efficiency.

CROSS CONNECTIONS[1]

By M'Kean Maffitt[2]

There has been so much said and so little done about cross connections in public water supply systems that it is hard for me to know where to start. It is harder to know what to say and hardest to know where to stop.

Cross connections are private water supply systems that are connected with the public water supply system. They exist in most of the cities and towns of the country where there is a public water supply and it has been shown that they are a menace to health. To my mind it has been proved beyond a doubt that they should not exist in such a manner that it is possible to get polluted water back into the public water supply from the private supply. Unless some immediate action is taken towards the elimination of these connections, and their prohibition in the future, they are going to increase as the industrial development of the communities increases. As I shall show later, every such cross connection is a positive and continuous source of danger to the public water supply system where there is a possibility of poluted water getting into the public water supply.

I would not place a burden on any industry by forcing it to do that which was not necessary for the protection of the health of the community. Nor will I knowingly allow industry to place any additional or unnecessary dangers upon the public water supply system. Therefore the question is, "Shall industry, for a small monetary consideration, endanger the health of the entire community; or shall industry spend a few hundreds of dollars in each individual case and free the community from a constant danger?"

If the heads of the various industries could see what they are doing in maintaining these connections, they would be tempted to force the responsible water works official out of office for allowing these connections to have been made.

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Superintendent of water, and City engineer, Wilmington, N. C.

My own experiences with cross connections show that they are very dangerous. Though my experience has been limited as compared with that of others, I am still of the opinion that such connections should not be allowed to exist.

In one case we had a 16 inch valve to cut in the line. Considerable trouble was experienced in getting a dry pipe so that we could work. We went over the valves several times, but failed to find the one that was leaking. Yet we knew that there was either a leaky valve or an unknown connection. The flow of water in the hole was about 200 gallons per minute. Remembering that there was a cross connection supplied from the section cut off we went to this connection and closed the gate valve on it. The flow of water ceased immediately. The check valve was leaking so badly that the private water supply system could not keep the pressure up and we were getting all of the water into our lines. Knowing this we took immediate steps towards the repairing of this valve and the washing out of the mains affected. Otherwise we should have had a polluted water supply and we would not have known where it came from.

This cross connection took water from the river within a few hundred feet of the largest sewer in town and at flood tide the sewage was carried up to the intake of the pumps. If increased pressure on the pipe lines on this cross connection had been necessary and had that pressure been above the city pressure we would have had the same trouble that so many other cities have had.

In another case we had a blow out at the pumping station that caused the water supply to be cut off for an entire day. During this time all of the private water supplies had their pumps running, which was a legitimate thing for them to do. Immediately after the supply was cut off I sent to all of the private supplies and had the gate valves controlling them closed. This was done as a precautionary measure. Had the gate valves leaked, as so many of them do, it would have been of little avail. At one connection, the foreman in looking for the gate valve opened the meter box and noticed that the meter was running backwards. How much water had run into the public supply system we do not know. This happened on a long dead end of 12-inch main and we were able properly to wash out this main as soon as the water supply was turned on again. We did not have, therefore, any trouble with this pollution.

These two cases show that it is possible to have leaky valves without being aware of it. If this condition does exist, some day you are going to get polluted water into the system and, for the time being, all the money that you have invested for a purification plant will be thrown into the discard and you may as well be pumping raw water.

If we do not make it impossible to get polluted water into the public water supply system, here is what may happen to your own city. These are just a few cases used as illustrations because they are so obvious in their results. There may have been many more that were gradually letting pollution into the water supply and were never detected.

Lowell, Mass., 172 cases typhoid, 9 deaths, and many cases dysentery
Lawrence Mass., Many cases typhoid, many deaths, many cases dysentery
Bloomington, Ill., 130 cases typhoid, 15 deaths, 400 cases dysentery
Rochester, N. Y., Many cases typhoid
Boston Mass., Several cases typhoid, deaths unknown
State of Rhode Island, 40 cases typhoid, 4 deaths
Franklin, N. J., 114 cases typhoid, 18 deths
State of Illinois, 800 cases typhoid, 75 deaths (5 outbreaks in state)
Rockaway, N. J., 41 cases typhoid, 4 deaths
Total of 1297 cases and 125 deaths of typhoid fever.

We know what caused these deaths. Are we to sit supinely by and let the other side say that these cross connections are not dangerous? They are dangerous and the sooner we see it and make it impossible to let this pollution into our water supplies the better will we be able to rest at night.

The insurance interests say that the check valve as designed and approved by them is sufficient to protect the water supply. If it is, how can you account for the following:

There have been reported,

19, plus many, check valves as leaking
3 gate valves as leaking
61 F. M. check valves as leaking in one valve
6 F. M. check valves as leaking in both valves
25, plus many, outbreaks of typhoid fever due to cross connections
4 outbreaks of fever due to by-passes
5 outbreaks of fever due to intakes
1 case contamination due to cross connection with deep well
1 case of F. M. check valve being held open by pair of overalls

If the public health is insufficient to cause drastic action, how about the financial costs of the epidemics. Taking the case at Lowell, Mass., with 172 cases and 9 deaths, Caleb M. Saville, Chief Engineer, Hartford, Conn., Water Board, estimates the costs at $100,000.

The question of a double supply of water for fire protection, one from the city supply and one from a polluted supply, where there is no physical connection between the two, has been solved by the over feed tank where the inlet pipe from the public water supply is higher than the over-flow pipe from the tank and where the over-flow pipe from the tank is so large that the fire pumps can not fill the tank to the supply pipe from the city supply. In this way, and as far as I can see in no other way, can we be assured that there will be no pollution from the private supply that can get into our mains.

Mr. President, I move that this Association go on record as follows:

There shall be no physical connection between the public water supply system and any private water supply system, wherein it is possible for contaminated water to pass to the public water supply system.

HENDERSONVILLE, N. C., GRAVITY WATER SUPPLY SYSTEM[1]

By Stanley H. Wright[2]

The city of Hendersonville lies on a plateau west of the Blue Ridge Mountains at an elevation 2250 feet above sea level. The city is situated on the main line of the Southern Railroad between Cincinnati and Charleston, 100 miles west of Charlotte, N. C. The permanent population is about 6000, but during the summer months the population increases to from 12,000 to 15,000.

The original water works, consisting of a crude reservoir fed by two small streams, was constructed in 1888 which by 1918 had become woefully inadequate. As a temporary measure a pumping station on another nearby stream was constructed and at this time a treatment plant installed. Even this additional supply did not give the amount of water required.

In 1921 the water commissioners of the city of Hendersonville, C. E. Brooks, Chairman, K. G. Morris, Secretary and Treasurer, and J. W. Bailey, in their interests for this community and the thousands of tourists that come to Hendersonville, procured what is said to be one of the finest water supplies east of the Rocky Mountains. The Commission is an appointed body distinctly separate from the other city officials. Through this Commission the State Legislature permitted the city to vote $600,000 in bonds to build a new water system, and in the summer of 1922 construction work began.

We think of pure air, wonderful skies and delightful scenery to be the natural attributes of any locality so fortunately placed that these things to the appreciative stimulate their minds and make their lives worth living. Water is usually so ready at hand, made available by the mere turning of a handle, that its quality, so long as it be clear, must often pass unnoticed.

So that all who so desire may drink their fill of natural water untreated, but absolutely pure and crystal-like in clearness, the city of

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Hydraulic Engineer, Gilbert C. White Co., Consulting Engineers, Durham, N. C.

Hendersonville has laid a 16-inch pipe line 17 miles west into the heart of the Pisgah National Forest Reserve. Here they have 20 miles of uninhabited water-shed entirely forest covered. Not a soul living upon the water-shed, nothing but the wild creatures of the forest which roam at will under the protection of the United States Government. Here one may find deer, bears, wildcats, ground hogs and many feathered creatures living without fear of mankind, as no one may enter the Forest Reserve who carries firearms.

At the junction of Big Creek and Fletcher Creek there has been constructed a masonry intake dam holding 5,000,000 gallons, at elevation 2450 feet above sea level. This dam diverts the water from the streams through the pipe line constructed over a private right-of-way into a distributing reservoir in Hendersonville.

The construction of the intake dam and pipe line involved many difficulties. The cast iron pipes, each piece weighing nearly a ton, had to be transported in many different ways to reach the rocky places so difficult of access. To deliver these pipes the contractors had to make use of trucks, tractors, 2-mule teams, 4-mule teams and oxen, while some pieces had to be lowered down precipitous sides by blocks and tackle. Up and down the hills, across many creeks and deep under the French Broad River, the pipe line is laid. Each mile of pipe is tested to see whether any pieces are defective or whether the joints are properly caulked. In some sections the pressure applied amounted to 250 pounds per square inch.

The intake dam is a masonry structure of the gravity type, built of cyclopean concrete with a cut stone face wall. It is located at the junction of Big Creek and Fletcher Creek; the two creeks at this point forming the North Fork of Mills River. Owing to the fact that the water in these two creeks is very clear and free from sediment, sand was unavailable, and it had to be imported from a source twenty miles away, making it cost, approximately, $9.00 a cubic yard. The stone for the face of the dam and for the concrete was quarried on the job. The difficult part in the construction of the dam was its inaccessibility. It is in a rough country and 20 miles from the nearest railroad. The last 3 miles before construction began was a foot trail up the river, fording it fifteen times. After the contract was let, the contractor widened the trail enough for a wagon to get through in dry weather. In wet weather it was practically impossible to do so with a load. A good team's capacity on this so-called road was $\frac{1}{2}$ cubic yard of sand, or 12 bags of cement, making only three loads a

day. Because of this long haul of 20 miles with sand and cement, and the light equipment used on the job, namely, a small cableway and a quarter yard mixer, construction progressed rather slowly.

The dam is a small structure, 180 feet long and 22 feet high at the deepest place. It contains about 700 cubic yards of concrete. Nevertheless, it is considered one of the most beautiful masonry structures of its type in the state.

The reservoir formed by the dam has a capacity of 5,000,000 gallons. There was little need of an impounding reservoir as the two streams together flow more (in the driest time) than the capacity of the pipe under the present head. Above the lake on each creek heavy timber racks were built to catch all logs and trash which might come down in flood. Immediately below the dam a masonry house, built of round river boulders, contains the Venturi meter.

The transmission line was built of 16-inch cast iron bell and spigot pipe, furnished by the United States Cast Iron Pipe and Foundry Company. All classes of pipe were used from A through to E to take care of the varying pressures along the line. The construction of this line was difficult in places, owing to the rough topography. The 4 miles from the intake to the foot of the mountains were the most difficult. On the steep slopes, some at approximately 45°, it was impossible to get the heavy pipe along the ditch without the use of teams with block and tackle to snake the pipe into place. At the creek crossings the pipe had to be laid below the bed of the stream and anchored there with concrete. At the French Broad and Mills River, cofferdams were built, the pipe laid several feet below the bed of the streams and anchored with concrete. There was quite a large amount of rock excavation, although not excessive for the mountain country.

Some idea of the amount of work involved in this project may be had when it is realized that 215,000 pounds of lead had to be melted and poured into the cast iron joints. Two hundred freight cars containing 7200 pieces of pipe were shipped into Hendersonville.

On this transmission line there are gate valves, approximately every 5000 feet, to aid in charging and testing the line, and to operate in emergencies. Air valves were put at all high points in the line and blow-off valves at all low places. The air valves are automatic, but the blow-offs require the attention of a man twice a year to open and close them, thereby cleaning out the line. The pipe discharges 2,300,000 gallons per twenty-four hours.

The distribution reservoir was built on top of a hill 1 mile west of the city. It is elliptical in shape with a division wall across the center, making two separate basins. Water can be taken from either basin or both. The reservoir was built by excavating the inside and building enbankments with the material excavated. The inside slopes and bottom were concreted; the outside slopes and top sodded. The capacity of each basin is 2,500,000 gallons, which is a six-day supply at the present time for the city.

The distribution system consists of a 16-inch supply pipe from the reservoir to Main Street, with 4-, 6- and 8-inch laterals on the most important streets. More than 7 miles of new 6-inch pipe, and 1 mile of 8-inch have been laid. Fire hydrants have been set not more than 500 feet apart. Steamer nozzles were used in the business section.

The new system gives Hendersonville an abundant supply of clear, pure water at no expense, save that of construction. The following are some of the outstanding features in the construction of the gravity pipe line:

Total head between intake dam and distributing reservoir	117 feet
Working pressure in Hendersonville on Main Street	90 pounds
Total length of pipe line to distributing reservoir	77,000 feet
Total length of line into Main Street, Hendersonville	84,240 feet
Estimated capacity of pipe line from intake into reservoir	2,300,000 gallons
Actual measured flow by venturi meter	2,320,000 gallons
Leakage—None that can be observed or measured by meter	
Maximum static pressure at lowest point in the line	175 pounds
Maximum pressure to which line has been subjected	250 pounds
Number of split pipe placed in the line or failed under pressure was 3 out of a total of 7020 pieces	

There was one serious joint blow-out under pressure.

Only 3 per cent of the total number of joints showed slight sweating and trifling leakage which required re-caulking.

Water was turned into the pipe line within sixteen days of the contract time, in spite of delays due to the railroad strike of 1922 and to rainy weather.

The contractor used no mechanical equipment whatever, other than a gasoline pump and the hand-winch unloading derrick. The lead for the joints, aggregating some 265,000 pounds, was melted in pots on open wood fires. All the pipe handling and caulking was done by hand.

The Kelly-Wilson Company of Asheville, N. C., were the contractors for the pipe line and the Virginia Machinery and Well Company of Richmond, Va., were the contractors for the intake dam and distributing reservoir. Both contractors are credited with performing first class work in every respect. The Gilbert C. White Co., of Durham, N. C., were the consulting engineers.

WHY FIRE CHIEF AND WATER WORKS SUPERINTENDENT MUST WORK TOGETHER[1]

By Sherwood Brockwell[2]

Ordinarily in giving a fire prevention talk, one tries to fit it to his audience, but the fire chief and superintendent of water works, the water department and the fire department are so closely allied that the problems of the one automatically become the problems of the other.

Every large city in North Carolina has made or is at present making extensive additions to the present system. We have installed many plants in our smaller towns, but too many of our 4000 and 5000 towns have not improved their water works and fire department facilities in keeping with their unprecedented growth, and this calls for dilligent and intelligent work from the individual superintendent and water works associations in general.

Another point I want to call your attention to is that on my desk at present there is correspondence from five cities and towns in North Carolina which have installed water works systems within the past ten years and have put down paved streets. Now with the water works practically new, they are confronted with the necessity of removing the newly laid pavement in order to make necessary extension throughout their business districts, showing that someone in authority, from a water works standpoint, was either short-sighted or the municipality, not expected to be up on such problems, has been allowed to invest in something which should be of undisputed benefit and yet has derived little benefit from the investment.

Some weeks ago there was a fire in a thickly settled residential portion of a North Carolina town. When the fire department arrived, a two-story, frame dwelling was pretty far gone. One line was attached to a pumper of 750 gallons, which in turn was attached to the nearest hydrant, about 750 feet away on a 4-inch main and an effective fire stream was produced. Presently the chief de-

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Fire Engineer, North Carolina Insurance Department, Raleigh, N. C.

cided to apply two lines and in a few moments both streams were idle. Before the trouble was located and remedied eight minutes had elapsed, a home was destroyed and a real serious fire narrowly averted.

Of course, no fair-minded man would have blamed the superintendent of water works for the chief of fire department using a flexible suction pipe, but that much property ought never to have been allowed to have been built up on a 4-inch main. There is an 8-inch line there now.

Another instance I recall was a furniture factory, located on the border of a thickly built residential section. When the department arrived, there was a great deal of smoke, but not much fire; 250 feet away there was a hydrant on a 4-inch main; 450 feet away there was a 6–inch main. The first line was stretched 450 feet off of the 6-inch main. Just as the water started a pumper was attached to the hydrant on the 4-inch, fed from the 6-inch main, and two lines stretched from this pumper. You know the result. As the pumper operated, the domestic pressure line went down. Then the second pumper was attached to the 6-inch main further up the line. Friction ate this line up while it was cutting all the others down. With both pumpers panting, the fire burned merrily on unmolested by an effective fire stream, while those whose homes were out of range stood by and cursed the fire department, water works, fire pumps, city officers and the whole works in general. In a following election they did defeat the three commissioners, the fire chief, and would have gotten the superintendent of water works had it not been for the fact that he is one of the best in the United States and absolutely the right man in the right place.

The superintendents are all ready to say that the chief was foolish and that the superintendent of water works was in no way open for criticism. The chief did the best he knew how. He did not know the difference between a 4-inch and a 6-inch main. A hydrant was to him a hydrant, that and nothing more.

I happen to know both men in this case personally. I know that the superintendent, a technically trained man, had spent hour after hour trying to explain those kinds of things to the chief, who, probably willing enough to learn, was incapable of taking such information. I know also that, in this day of modern water systems, there was no place for the 4- or even the 6-inch main.

There is no man in your town more capable of knowing the fire chief's ability than the superintendent of the water works, and I might add that the opposite is true.

The great difference lies in the fact that most cities have learned that the water works superintendent should have technical training before being appointed and have looked to this end when filling such positions, while the average fire chief is left to acquire his training after being given the responsibilities.

The point is that a large part of the water works business is fire protection. When we consider that there were 15,000 Americans burned to death last year and over five hundred million dollars worth of property destroyed, it is time for us to realize that, if your town is large enough to have a water works system, there are fire conditions existing therein, which require your putting shoulder to shoulder along side of the fire chief. Each must know his part and coöperate.

Your training puts you in the position of being the big brother in all things hydraulic. You will find the little brother anxious to do his part.

There never has been a good fire chief who did not appreciate the big brother attitude. There is no room in modern fire protection for either a chief or a superintendent who will not push for better water, more water protection in newly built-up sections, anti-combustible roof ordinances, public sentiment against promiscuous handling of gasoline, laws against sleeping quarters over garages, better buildings, safer schools, and hundreds of other things you two can accomplish together.

Too much of our state and national fire loss has been due to the lack of true coöperation between fire chief and water superintendent. One has been too prone to ignore the duty and limitation of the other and the other has too long been indifferent to the needs and problems of his brother in service.

There has been too much pressure gauge reading and fire report reading in the form of alibis. My closing plea is, fire protection is big enough for both of us.

DRILLING, CARE AND OPERATION OF DEEP WELLS[1]

By Chas. F. Cole[2]

The first thought that comes into the mind of the water works engineer is "Can we get a satisfactory surface source of water supply?" Frequently this is not available, particularly in the case of small towns and this is where the use of drilled wells flourishes. No deep well driller worthy of the name recommends drilled wells where the size of the town warrants an extensive and expensive water system from a surface supply within a reasonable distance. The exception to this rule is that in the coastal plain frequently a large yield of water may be obtained from a series of wells at moderate cost to supply towns of considerable size.

The second thought that comes to mind is, "What is the prospect of obtaining water from a well or wells and what is the best location for the well," always bearing in mind that the highest authority in the State, the State Board of Health, must approve the site of the well.

There is no fixed rule or set of conditions to guide us in locating a well so as to insure an adequate yield of water within a reasonable depth. It is largely a case of betting on your hand and a gambling chance to win.

However, there are certain suggestions I should like to present based on some twenty-five years experience and observation. It is not good practice to locate the well on high hills or ridges, nor in low dales or swamps—for the rocks conform to some extent to the surface topography and are more likely to be "hog backs" on hills or ridges shedding water and not have sufficient crevices or faults to permit of the seepage or filtration of water along these veins into the bore hole or well.

Placing a well in a low valley with surrounding hills means that the well frequently penetrates disintegrated and broken up formations which do not hold water. Further, quicksand or a fine running

[1] Presented before the North Carolina Section meeting, November 15, 1923.

[2] President, Virginia Machinery and Well Co., Richmond, Va.

sand is likely to be encountered on top of the rock which it may be difficult to eliminate from the well by casing. Furthermore, the drainage from contaminating influences more easily penetrate a well so located.

Generally speaking a hillside site is preferable so as to bisect and intersect the crevices and faults which, more often than not, will lie at an angle to the surface of 20° to 60°. These crevices frequently bisect each other, so that water may come into the well from a crevice which bisects the one penetrated by the drill.

What I have said applies more particularly to the Piedmont Section and to the crystalline rocks than to the Mountain or Coastal Plain Sections of the State.

There is a fairly well defined section of North Carolina quite wide in area and extending practically across the State and into South Carolina where shale and slate formations predominate. In this section and in these formations particularly, it is difficult to obtain large yields of water from drilled wells, and the deeper the well the less likely it is to prove satisfactory, certainly if in a formation partaking of slate. The axis of this line might be said to run diagonally through the State from Roxboro on the North, through Durham, Sanford, Marshville and on into South Carolina through Chesterfield.

West of this line there is a stratum of very hard rock which lies more like a pocket in the center of the State, taking in Randleman, Asheboro, Ramseur, Albemarle and Troy, in which it is also quite unlikely that large yields may be expected. The country in which this rock occurs is noted for the quartz boulders which lie on the surface, in many places so thick as to make the land worthless agriculturally.

In the Coastal Plain, which is divided from the Piedmont by the Fall line which runs through the State approximately from Weldon to Selma, then bending Southwest to Hamlet, wells can be counted on with much more certainty to furnish a good supply. In many parts of this section they flow. In sand wells the problem is to determine the best sand strata to develop and to use strainers of such mesh or orifice of inlet as to let in the water and to keep out the sand; not to have the strainer so fine as to clog the well nor yet so coarse as to permit fine sand to flow constantly into the well; and in the case of a deep well pump, choke up the valves, cut out the leathers and cylinder or working barrel. Generally speaking

the coarser the strainer the better it is for permanency of yield and freedom from operating troubles. It is almost invariably true that a brass strainer of special construction is more durable than a pipe strainer.

The pumping of a sand well can be done more satisfactorily with air as a rule than with a deep well pump, as there are no working parts in the well with an air lift. It is also true that air lift pumping is notoriously inefficient in economy.

When it is determined to pump with air, it is often not necessary to use a strainer in finishing the well, particularly if the strata be coarse and the flow or yield strong, as the air soon exhausts the fine sand, leaving the coarse sand and gravel to serve as a filter bed.

So much for the practice of locating a well.

With regard to the mechanical features of drilling and developing a well I would say

First, get a good well driller.

Second, use as few restrictions as your conscience will permit in hedging him about in your specifications, consult him freely as to his opinion and use his advice or not as you like.

In a rock well I would suggest that the well be specified at least one size larger in diameter than you expect the finished size to be, as it may not be practicable to drill the well the same diameter from start to finish. Loose rock may fall in which interferes with the drilling and endangers the operation so that it is not safe for the driller to proceed unless it is cased out. Running sand may be encountered which it is necessary or desirable to cut out. An undesirable water may have to be cased off. Ordinarily a well starting 10 inches in diameter is large enough and this may finish 10 or in most cases 8 inches which is sufficiently large in diameter to permit of the use of a deep well pump of 120 g.p.m. capacity.

The well should be lined to the rock with full weight genuine wrought iron drive pipe, with recessed drive couplings. This is more for the protection of the owner than the driller, as it is generally conceded that wrought iron lasts far longer than steel, particularly when exposed to the chemical action of some soils, and the oxidation due to water. A wrought forged steel drive shoe should be used on the bottom end of the pipe to facilitate driving the pipe and to protect the end of it so that it will seat squarely on or in the rock and eliminate surface water. As rock is a little soft usually and disintegrated on top or where it joins with the clay this shoe and pipe can usually be driven a short distance into the rock.

Should any of the contingencies arise necessitating reducing the bore of the well, it should be telescoped or relined from the surface of the ground to the point of reduction of diameter with the same character of pipe and shoe with which it is lined to the rock.

Above all, the well should be drilled straight so as to permit the use of the largest size pipe and cylinder that the yield of the well will afford.

Generally speaking, very deep wells are not profitable in yield of water, around 500 or 600 feet usually being the point beyond which it is not desirable to go.

Adequate testing of the well is most important. A twenty-four-hour continuous test is as short a time as it is safe to determine the permanency of the yield. Longer tests are desirable.

As the pumping head, i.e., the point to which the water drops and remains constant while the well is being pumped, is usually within 200 feet from the surface, it is ordinarily not necessary to have the test cylinder placed lower than this. If the pump takes air with the cylinder placed at this depth, the well usually has a poor yield. A test of approximately 100 g.p.m. is within the capacity of the equipment of a well equipped driller. Testing with air in a sand well is desirable and the good driller is equipped to do it.

In a sand well, it is frequently necessary to sand bucket or sand pump the water bearing sand for quite a while to determine whether the sand is a good yielder of water and coarse enough to develop satisfactorily. Provision should be made for this in the specifications.

There are many ways to pump a deep well. Of course a flowing well delivering water directly into a reservoir is ideal, but is seldom found. In fact, there are few wells which do not require the use of an air lift or deep well cylinder or a moving element.

It is always well to make the bore of sufficient size to permit the use of a working barrel of the capacity required, although, if it is intended to use air permanently, the well can be considerably smaller than if some other type of pump be used.

From a 6-inch well as much as 200 g.p.m. may be pumped with air, while the same well will admit a working barrel which at the maximum will not deliver over 75 g.p.m.

A 12-inch or larger well will permit the use of a deep well centrifugal pump with a capacity of 500 g.p.m., provided the water does not drop too low in the well while pumping.

An impeller type of pump may be used in wells as small as 6-inch and these have a capacity of 100 g.p.m. and up. This type of pump is quite expensive and not very efficient, nor are they tried and true as are the air lift, plunger pump or deep well centrifugal. The most efficient deep well pump is the double plunger, double rod continuous flow pump, with which the column of water is kept continuously in motion from start to finish. A pump of this type under favorable conditions will operate with as high as 80 per cent mechanical efficiency. Because of its design the frequent breaking of rods, the jar and vibration incident to the single acting, single plunger pump, will be avoided. A double acting cylinder with guided rod is fairly efficient and more satisfactory than a single acting cylinder, though the water must come to a stop at the end of each stroke with this pump.

Chain drives for direct connected pumps are equivalent to motor drive direct connected and are more flexible, combining the flexibility of belt drive with the sureness and positiveness of gear drive. Slow speeds are preferable for plunger pumps with motor speeds not exceeding 1200 r.p.m. Slip ring motors are better than squirrel cage.

Air chambers on the discharge line are essential, preferably of large size. Check valves with rubber valves, spring loaded, promote quietness of operation and prevent leakage back into the well.

Periodically the rods, pipe and cylinder of a plunger pump should be examined to see that all threads and joints are tight to avoid any part dropping off in the well.

No deep well pump should be permitted to take air. If this condition develops the speed should be changed or the cylinder dropped lower in the well.

A convenient arrangement for pulling the rods of a deep well pump is a winch or cat head attached to the pinion shaft. This works out nicely with motor drive.

THE RELATION OF HARDNESS IN WATER SUPPLY TO PUBLIC HEALTH[1]

By E. Sherman Chase[2]

One of the questions water works men are frequently called upon to answer is "How does the hardness of a drinking water affect health?" The answer to this question may be sought by means of physiological and medical research or by a study of mortality statistics. The following paper deals with the latter line of inquiry and consists of a comparison of statistical data relative to mortality from certain selected diseases amongst populations supplied with "soft" water with similar data for populations supplied with "hard" water.

POPULATIONS CONSIDERED

The populations supplied with soft water, which are here considered, are the urban populations of the two New England states of Massachusetts and Connecticut. The hardness of the water supplies of the cities of these states will range from approximately 10 to 30 parts per million (the Wachusett supply of the Boston Metropolitan District has a hardness of about 10).

The populations supplied with hard water which are considered are the urban populations of the middle west states of Ohio and Michigan. The hardness of the water supplies of these states will range from approximately 100 to 250 parts per million, about 10 times that of the waters of the two New England states.

The populations of the urban communities of these four states are reasonably comparable. The principal cities are industrial centers and probably contain approximately the same proportions of foreign populations. The age distribution is also very nearly the same in all cases with a slightly larger proportion of children in the two western states. The age distribution is shown by table 1.

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 24, 1923.

[2] Sanitary Engineer, Metcalf and Eddy, Boston, Mass.

This table shows that, in the case of the age groups 45 and above, the proportions in the four states are very nearly the same. This is a particularly important consideration in dealing with the particular diseases which have been selected for comparison, as these diseases occur mainly in the higher age groups.

TABLE 1

Distribution of urban population by age groups (United States Census 1910)

AGES	MASSACHUSETTS	CONNECTICUT	OHIO	MICHIGAN
years				
Under 5	9.8	10.1	10.1	10.6
5– 9	8.8	9.1	9.2	9.8
10–14	8.5	8.5	8.9	9.2
15–19	8.8	9.1	9.4	9.5
20–24	9.7	9.7	9.5	9.4
25–29	9.3	9.1	9.0	8.6
30–34	8.3	8.1	7.9	7.5
35–44	14.9	14.4	13.7	12.9
45–54	10.5	10.2	10.2	10.2
55–64	6.2	6.2	6.6	6.6
65 and over	5.2	5.3	5.5	5.6

DISEASES CONSIDERED

From the International Classification of Causes of Death as given in the Mortality Statistics of the United States Census, some six diseases have been selected as ones which might conceivably be affected by the hardness or the softness of water supplies. These diseases are: diseases of the arteries, atheroma, aneurism, etc; biliary calculi; acute nephritis; Bright's disease; calculi of the urinary passages; and diseases of the bladder. Whether there is any physiological evidence to show that these diseases are affected by the degree of hardness of drinking water is not within the scope of this paper. It may be stated in passing, however, that published opinions in this matter are somewhat conflicting. It is believed, however, that the six diseases selected cover a sufficiently inclusive range for the purposes of this study.

COMPARISON OF DEATH RATES

Table 2 gives the deaths for diseases of the arteries, per 100,000 population, for the four urban populations considered and for the

three years 1915 to 1917. The years selected are such that the disturbing effect of the war period with respect to age distribution and other abnormal conditions is avoided. The rates are taken from the annual mortality reports of the Federal Census.

This table indicates that, in the case of diseases of the arteries, the advantage, if any, lies with the populations supplied with hard water. It must be noted, however, that the Connecticut cities have the lowest death rate of this disease of any of the four urban popula-

TABLE 2

Diseases of the arteries (Int. No. 81) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	36.7	22.7	25.2	25.8
1916	41.0	27.0	27.3	33.4
1917	46.9	28.7	28.3	32.2
Average.....	41.5	26.1	26.9	30.5
Group average.	33.8		28.7	

TABLE 3

Biliary calculi (Int. No. 114) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	4.2	4.4	5.2	4.3
1916	4.3	3.4	4.9	4.4
1917	4.6	3.5	5.3	4.0
Average.....	4.4	3.8	5.1	4.2
Group average.	4.1		4.7	

tions and it does not appear that the evidence warrants attributing any material effect of water supply hardness upon diseases of the arteries.

Table 3 is similar to table 2, but deals with deaths from biliary calculi.

From this table it would appear that a slight advantage with respect to deaths from biliary calculi rests with populations supplied by soft water. It should be noted, however, that the Massachusetts

rates are higher than those for Michigan. It accordingly seems doubtful whether these figures indicate any real or material advantage, as far as deaths from biliary calculi are concerned.

Table 4 is similar to the preceding, but with acute nephritis as the cause of death considered.

Here again there appears to be a slight advantage for the soft waters, but it will be noted that Connecticut has a higher rate from this cause than either of the hard water states. The low rate in

TABLE 4

Acute nephritis (Int. No. 119) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	7.0	10.8	11.6	9.8
1916	6.5	13.8	10.2	9.4
1917	6.2	13.6	10.2	10.1
Average.....	6.6	12.7	10.7	9.8
Group average.	9.65		10.25	

TABLE 5

Brights disease (Int. No. 120) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	84.5	106.7	87.0	74.9
1916	88.8	113.6	88.2	75.5
1917	87.6	115.9	91.0	79.3
Average.....	87.0	112.1	88.7	76.8
Group average.	99.5		82.7	

Massachusetts is responsible for the low average rate for the soft water populations.

Table 5 is also similar to the preceding tables, but comparing the death rate for Bright's disease.

This table indicates an advantage for the hard water districts, in Bright's disease, due mainly to the materially higher rate for this disease in the cities of Connecticut than in the cities of the other states. The high death rates from kidney disease (nephritis and

Bright's disease) in Connecticut are probably the result of some local condition which is not readily apparent. It will be noted that the Massachusetts rate, while higher than the Michigan rate, is almost the same as the rate in Ohio. From the evidence presented in this table, however, it cannot be stated with any degree of positiveness that the hardness or softness of water supplies has any clearly defined effect upon the death rate from Bright's disease.

TABLE 6

Calculi of the urinary passages (Int. No. 123) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	1.2	0.7	0.8	1.1
1916	0.8	0.8	1.0	0.6
1917	0.8	0.2	0.9	0.9
Average.....	0.93	0.57	0.90	0.87
Group average.	0.75		0.88	

TABLE 7

Diseases of the bladder (Int. No. 124) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	4.3	2.1	1.3	1.9
1916	1.0	1.2	1.4	2.3
1917	1.3	1.0	1.0	1.9
Average.....	1.20	1.43	1.23	2.03
Group average.	1.32		1.63	

A comparison of the death rates from calculi of the urinary passages, one of the diseases which is frequently referred to as being aggravated by hard water is given in table 6.

The figures given do not indicate that this disease is materially affected by hard water. It is true that the average death rate from this disease during the three years studied is lower for Massachusetts and Connecticut than for Ohio and Michigan, but the lower average for the soft water states results from the low death rate in Con-

necticut for the year 1917. Further evidence would be required to demonstrate conclusively that hard water increases the number of deaths from calculi of the urinary passages.

Table 7 gives a comparison of the death rates from diseases of the bladder.

While this table shows a somewhat lower average death rate from diseases of the bladder in Massachusetts and Connecticut than in Ohio and Michigan, the difference is slight. Furthermore, Connecticut has a higher rate than Ohio, and Ohio and Massachusetts have almost the same rates, Michigan rates being higher than any of the other three. This table, therefore, cannot be considered as establishing any clear connection between the hardness of water supplies and the death rates from bladder diseases.

CONCLUSIONS

From this brief and rather limited study of mortality rates, the tentative conclusion may be reached that the statistical evidence indicates no relation between hardness in drinking water and deaths from diseases of the arteries, kidneys, or bladder. It would be of interest, however, to extend this inquiry by making a more detailed study of mortality in specific municipalities with water supplies of various degrees of hardness and with various proportions of permanent and temporary hardness. In the case of cities using softened water supplies, it would also be of interest to compare mortality rates before and after the softening plants were put into service.

DISCUSSION

Louis L. Tribus:[3] Probably a large number of white Americans, and many inhabitants of the more enlightened European lands, have grown up with the idea that the quality of waters for drinking purposes has much to do with individuals and public health. There is no question that from bacteriological standpoints this is the case, and that there may be some effect from those having very considerable mineral content.

We are viewing the case solely from the human consumption side, not from use of soap, deposition in boilers, piping, etc.

There has been a very general impression, backed extensively by physicians, that "hard" waters are trying to the kidneys, may

[3] With Tribus and Massa, Consulting Engineers, New York, N. Y.

produce gall stones, and some go so far even as to suggest goitre as a consequent evil.

The usual "hard" elements of hard waters are such minerals as are not deposited at temperatures below the boiling point, do not readily oxidize, and are not generally soluble in the juices of the digestive system, so have every good reason for passing out of the body in practically the same chemical status as at time of entering.

Various therapeutic springs are much sought for and some habitues credit them with great cures. We would not deny that some human systems are helped by the alkali ingredients of some waters which may attract their excess of acids, though we believe that rest and imagination have much to do with the case, and far more the extensive and unusual water flushing that the water cure visitor indulges in.

A few months ago a well-known medical writer was sought for advice through a newspaper. Let us quote the letter and the reply:

Mrs. B. F.—Several years ago an examining physician for an insurance company advised me to drink only soft spring water, as I have a tendency to nephritis, but I have not done so for more than three years. The water in my home is exceedingly hard and I have had two attacks of acute kidney disease during the year I have lived here.

The Answer

Water is hard or soft according as it contains more or less foreign ingredients in solution, particularly mineral matter.

The softest water is distilled water or pure rain water but the latter is seldom obtainable, for it is almost sure to dissolve some kind of foreign material from the moment it reaches the earth.

If the water you are drinking is very hard—that is, contains much mineral—and your kidney disease, whether inflammation or formation of stone, seems traceable to this source, I would advise you to use only distilled water.

The advice was good, well qualified by "ifs," but seemed worthy of further thought.

A rather lengthy letter of inquiry was sent to the Editor-Physician, as to whether he had any *authentic* information from his practice, or that of others, where the drinking of hard water had been known to produce any intestinal disability.

The reply was that, in his large practice, it had become common knowledge that the drinking of hard waters was undesirable; but he gave no conclusive evidence.

The writer had given him some data upon which to draw out comment, but failed to elicit anything definite; the data may perhaps be repeated here in part so as to bring out some discussion:

As waters go, mineral contents, not removable by filtration, ranging from 50 to 300, or more, parts per million, class as "hard."

Some time ago in our water supply practice certain ones in the particular community at issue insisted that "hardness" in the local supply was the chief cause of gall-stones and also injuriously affected the kidneys. We had had personal experience with water supplies in various parts of the country and had not encountered any special trouble chargeable to hardness; but we took up the question locally, and with the Departments of Health of Massachusetts, New York, New Jersey, Pennsylvania and Kansas, covering thus a wide range of potable waters, and in every instance, after quite full study, reply came that, no instances were known to the Departments where "hardness" had been reported as the cause of any intestinal or organic disability.

Locally we found no proof, only some claims which were more likely to have been imaginative than real. Have any of our water friends anything to add? Perhaps something definite can be presented as to relationship of hard water to rheumatism.

TASTE AND ODOR IN CHLORINATED WATER[1]

By R. M. Warren[2] and Edward Bartow[2]

Taste and odors in water arise from two main conditions created by modern factory practice and habits of domestic life. The increased amount of factory waste plus city sewage on the one hand and a demand for a higher purity and agreeableness on the other often create an acute situation.

Taste and odor are intangibles, for their origin and nature are frequently hard to ascertain and measure. What is disagreeable to one person may not be to another. Therefore, a classification as to quality and quantity is almost impossible.

The system of measurement which is used in this work is described in the Standard Methods of Water Analysis of the American Public Health Association.

Numbers varying from 0 to 5 are assigned to odors of varying intensity. The numbers indicate roughly whether the odor is noticeable to an inexperienced person; to an experienced person; whether it is unpalatable or undrinkable.

Taste and odors have been attributed to bleaching powder and chlorine used in water treatment.

Chlorine was known to be germicidal as far back as 1881, when Koch used bleaching powder for germicidal purposes, but it was not until 1908 that calcium hypochlorite was used for municipal water works. At the Bubbly Creek plant at the stock yards in Chicago and at the Boonton reservoir of Jersey City, it was first found to be of value in water treatment and its use has grown rapidly.

Hypochlorite is troublesome due to its bulk and the loss of chlorine during storage. In 1911 liquid chlorine began to be used. Now the water used by hundreds of towns, including New York using 550 million gallons of water per day and Chicago using 700 million gallons, is treated with liquid chlorine.

[1] Presented before the Iowa Section meeting, November 1, 1922.

[2] Department of Chemistry, University of Iowa, Iowa City, Iowa.

Since the use of chlorine was started there have been several notable cases of taste and odor. In 1910 Milwaukee first met with trouble from the United States Phenol Plant at Carrollville and from the adjacent gas and coke companies. This trouble lasted over a period of several years and ended only when the phenol plant was closed and the local gas and coke companies discharged their waste at a point distant from the city intake pipes. There has been similar trouble in towns along the Monongahela river in Pennsylvania.

In some cases steps have been taken to remove taste and odor, while in others steps have been taken to prevent them.

Some of the methods used to remove taste and odor are:

1. Powdered coke and charcoal in contact with the water followed by filtration.
2. Hydrogen peroxide and several per salts, e.g., per-carbonates.
3. Sulphur dioxide which is recommended and used by Sir Alexander Houston.
4. Permanganates.

The methods used to prevent taste and odor are:

1. Aeration and storage before chlorination.
2. Care of watersheds.
3. Control of the amount of chlorine.

A symposium held in 1921 by *Engineering News-Record* shows opinions which are held by American operators concerning the use of liquid chlorine. The conclusions drawn by the editor relating to taste and odor are as follows:

1. The variation as to amount of chlorine, time of contact, etc., is due to different characteristics of suspended and dissolved foreign matter in water.
2. Substances other than water react with chlorine to give disagreeable compounds. Taste is not of chlorine or of HOCL and HCl as expressed in the equation:

$$Cl_2 + H_2O \rightleftarrows HCl + HOCL.$$

Water is sufficiently alkaline to prevent acid formation in free state.

3. Cold water troubles are due to other factors than chlorine.
4. No limit can be placed on amount of residual chlorine which will produce taste.
5. Well water with 0.01 p.p.m. may taste. Surface water with 0.8 p.p.m. may not taste.
6. After certain limits up to 600 to 1000 units per cubic centimeter an algae infested water requires more chlorine.
7. Chlorination has come to stay in water treatment.

It can be seen from the reports mentioned above that taste and odor arise from many different conditions. Turbidity has been found to affect the amount of chlorine necessary and, therefore, the taste and odor developed. Temperature also affects the amount of chlorine that can be added. (In using hypochlorite, six pounds per million gallons could be used during fall and winter.) Organic matter plays a large part, its nature and amount being a determining factor.

It is the opinion of some investigators and operators that taste and odor are due principally to the excess of chlorine above that needed for sterilization. Wolman and Enslow and Sperry and Billings are the strongest advocates of this relationship between chlorination and taste and odor developed. So far nothing definite has been proven concerning the variability of taste and odor with the amount of chlorine present, with oxygen consumed or with chlorine absorbed in a given time.

The present work was carried out in search of some relation between taste and odor and chlorine, to see what effect certain treatment, such as aeration and standing, would have on the taste and odor developed from chlorine.

Waters from different sources differ in many ways and the results of chlorination naturally vary greatly. Waters of different character were used in these experiments.

The first experiment was made in an attempt to determine the amount of chlorine required to give a taste in a water of highest purity, i.e., distilled water.

This amount was determined by Bartow and Van Brunt to be 3 p.p.m. in distilled water, but the following data from the writer's own experiment are presented further to justify this amount in the present work.

SAMPLE	CHLORINE	TASTE	ODOR
	p.p.m.		
1	1.7	0	1
2	3.4	3	3
3	6.8	4	4
4	13.6	5	5

This experiment was carried out in beakers containing varying amounts of applied chlorine with the result that 3 p.p.m. had to be applied to give a taste which would be disagreeable.

An amount less than this was chosen for subsequent experiments, so that taste and odor would be due to action on impurities present rather than chlorine.

An experiment carried out with river water containing varying amounts of organic matter, such as algae, shows a direct ratio between the amount of impurities present and the taste and odor developed.

To make the relation clear the table below is given to correlate the parts per million of chlorine absorbed and resulting taste and odor. All observations were made on the same samples.

JAR	OXYGEN CONSUMED	TEN MINUTES			THIRTY MINUTES			SIXTY MINUTES		
		Chlorine absorbed	Taste	Odor	Chlorine absorbed	Taste	Odor	Chlorine absorbed	Taste	Odor
1	20.8	1.8	5	5	1.9	5	5	2.0	5	5
2	9.9	1.7	5	5	1.8	5	5	1.9	5	5
3	9.5	1.6	5	5	1.8	5	5	1.8		
4	5.5	1.1	3	4	1.7	3	4	(2.0)	2	3
5	3.8	0.9	4	5	1.3	2	1	1.7	2	3
6	0.1	0.6	4	4	0.9	3	3	0.9	3	4

The same experiment shows that, measured by oxygen consumed, chlorine absorbed also varies with organic matter present. This would indicate that taste and odor vary with chlorine consumed rather than residual chlorine.

RIVER WATER, EFFECT OF AERATION

The aeration experiment is made further to associate the phenomenon of taste and odor with amount of chlorine present and the amount of oxidized materials present. The amount of chlorine absorbed was the measure of oxidized material in the previous experiment. No means were used to measure the oxidized material, it being assumed that the more organic matter present in the beginning the greater amount of chlorine absorbed.

When excess chlorine was added compressed air was used. All six bottles were connected to one bottle containing a stopper with seven holes, one hole for air inlet and the other six for outlets to the six bottles.

The following table shows the relationship. The same jars and material of the previous experiment were used, after the end of the sixty minute absorption period.

JAR	AERATED ONE-HALF HOUR			STANDING CLOSED FIVE HOURS		
	Cl_2 residual	Taste	Odor	Cl_2 residual	Taste	Odor
1	0	4	2	0	5	5
2	1	4	1	0	4	4
3	1	3	1	0	3	3
4	(0)	2	1	0	1	2
5	0.3	2	1	0	2	1
6	0.3	1	2	0	2	2

The conclusions may be summarized as follows:

1. Aeration removes some taste and much odor.
2. Presence of chlorine increases odor, but is not essential to it.
3. Taste varies as the amount of oxidized material present, while odor becomes constant after treatment.
4. On standing, even more oxidation takes place and, with no escape, the bad taste and odor accumulates.
5. Standing in open or aeration should be good treatment for water after chlorination.

STUDIES MADE ON GAS HOUSE WASTE

Among the numerous industrial wastes giving trouble in water purification, gas house waste take first place.

The first thing one would want to know is how much gas waste could be in water with no taste and odor before chlorination. The following experiment was made to answer this question concerning the water gas waste from the local plant. This would be about typical of any gas waste going into streams and rivers. The waste that was used in this experiment is called "drip water." It is the water which condenses in the storage tank and collects in a tank just outside. The oily material settles to the top and the suspended matter to the bottom. The clear brown liquid in the middle was siphoned and used.

Five hundred cubic centimeters of distilled water containing varying amounts of waste were observed as follows:

PARTS PER MILLION	PER CENT	TASTE	ODOR
80	0.008	Slight	Marked
40	0.004	None	Slight
20	0.002	None	None

Water would have to contain around 80 p.p.m. or 0.008 per cent to be disagreeable, if clarified and used unchlorinated.

Five hundred cubic centimeters of distilled water treated with varying amounts of gas waste and 1 p.p.m. of chlorine were used for observations to determine how much of the water gas waste would give taste and odor. One part per million of chlorine with one part per million of waste gives taste.

As in the case of river water, the odor is found to decrease faster than taste, both by standing and by decreasing the amount of waste.

CONCLUSIONS

1. Chlorinated water may have taste other than that given by excess chlorine.
2. Taste and odor may be developed by other oxidizing agents than chlorine and generally increases with chlorine absorbed.
3. Aeration may increase taste by further oxidation rather than remove it.
4. Oxygen consumed method of control good only where taste and odor are due only to excess chlorine.
5. Water should have access to air to give escape to odors developed.
6. For any given water there is an oxygen consumed value above which chlorine will give taste and odor. When this limit is reached, some method of oxidation should be used before sedimentation and filtration, so as to give opportunity for dissipation of taste and odor during treatment and before final chlorination.
7. Colorimetric method not accurate, if water contains any appreciable amount of phenol or cresol.

OPTIMUM HYDROGEN ION CONCENTRATIONS FOR COAGULATION OF VARIOUS WATERS[1]

By G. F. Catlett[2]

At a conference of engineers and filter plant superintendents of the Southeastern States, held at Atlanta in July, 1922, Mr. E. J. Theriault described comprehensively results obtained by the United States Public Health Service in an exhaustive laboratory study of the value of hydrogen ion concentration in the control of coagulation at water purification plants. This study was made for the most part on artificially prepared turbidities and added buffers, although some results were obtained on natural Potomac river water. As described by Mr. Theriault the indications were that this determination would be of the greatest value to the filter plant man in controlling his dosage, so as to secure economy of chemicals, efficiency in filtration, the elimination of coagulant in filter effluent and possibly the prevention of the corrosive action of certain low alkalinity filter plant effluents.

As suggested by Mr. Theriault this laboratory research had reached the stage, when the next logical procedure was the application of the same line of investigation to the actual conditions found in various municipal water plants. With this idea in mind, a series of tests were undertaken by the North Carolina State Department of Health, on the various public water supplies in that State. As the types of water supply found in this State vary from the highly colored swamp waters of the Atlantic Seaboard to the clear mountain supplies of the Blue Ridge, it was felt that conditions were favorable for such studies. The important questions to be determined were:

1. What constitutes the optimum hydrogen ion concentration in various waters?

2. Does the holding of the water treatment to such values result in improved efficiency and economy in plant results and is it practicable to secure such control?

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Principal Assistant Engineer, State Board of Health, Raleigh, N. C.

3. Can a dependable method be devised for determining hydrogen ion concentration that may be used successfully by the average plant operator.

METHOD OF MAKING THE DETERMINATION

The determination of hydrogen ion concentration by electrical methods was not considered, as the apparatus is too expensive for the small water plant and the technique too elaborate for the average operator. For the large plants it is entirely suitable and, of course, furnishes the most reliable figures. It is also useful for standardizing the color methods.

In order to arrive at a suitable colorimetric technique, tests were started at the Wilmington, N. C., plant. Close coöperation and assistance was furnished by Mr. Geo. D. Norcom, the superintendent of filtration. The standards supplied by the LaMotte Chemical Company were first tried, but were found unsatisfactory as regards permanence, the methyl red standards especially spoiling very quickly. Pure chemicals were next secured and buffer solutions made, from which standards could be made up as needed. Very good results were obtained in this way, but only a well trained chemist with a good laboratory could be relied upon to make such standards.

In *The Determination of Hydrogen Ion Concentration* by Dr. W. M. Clark a color chart is shown reproducing the colors of the various standards, made in accordance with the method of Clark and Lubs. It was found that using these charts in place of the tube standards gave satisfactory results that compared very favorably with tubes made from standard buffer solutions and with fresh LaMotte Chemical Company standards. In order to check possible variation due to the personal equation, determinations were made using tube standards and color chart, and by several observers, some of whom had had no previous experience in this class of work. The results showed close agreement and sufficient accuracy to warrant using charts for the purpose of water treatment control.

In order to carry out this technique it is only necessary to have one of the charts, which are sold separately from book, some indicator solutions, tubes graduated to hold 10 cc., a 1 cc. pipette graduated in tenths, and a bottle of distilled water. The indicator solutions are made from the dry powder purchased from LaMotte Chemical Company and in accordance with Clark's method, except that after rubbing up the dry indicator in a mortar with the

specified quantities of N/20 soda, the final dilution was made with 85 per cent ethyl alcohol instead of distilled water. These solutions are 20 times too strong in case of methyl red and 10 times too strong in the case of the other indicators.

It is necessary to make these concentrations in order to secure keeping qualities, and for making the tests they must be diluted with distilled water. The concentrated alcoholic solutions seem to keep almost indefinitely, a set having been used over a period of eight months with no deterioration. All of the tests given in table 1 were made by this method, with sufficient checking by tube standards to insure the uniformity of results. It is a significant fact that tests made on the same water at beginning of the eight months showed the same results as at the end of this time, although the same stock indicator solutions were used for entire period. The colors on the charts do not seem to fade appreciably and they are cheap enough to make their replacement no obstacle.

This technique seems to meet the needs of the small plant operator, and as described forms a much simpler test than the determination of alkalinity by titration with acid.

DETERMINATION OF OPTIMA

Clark and Theriault (Public Health Reports February 2, 1923) state that as a result of their investigation: "When other possible factors are left out of consideration, optimum conditions for floc formation will be found with a narrow zone of pH centered for dilute solutions at pH 5.5." J. R. Baylis (*Proc. American Society Civil Engineers*, December, 1921) gives an optimum for Baltimore city water at 6.5. Wagner and Enslow (*Journal American Water Works Association*, May, 1922) give an optimum zone for "non organic" waters 6.5 to 7.0 and for "organic waters" a zone as low as 5.7 and never above 6.5. These figures indicate quite a variation in optima.

Tables 1, 2 and 3 give optima determined on a number of North Carolina waters. Those in table 1 check the figure set by Clark and Theriault. These waters are practically all located in the east central part of the State and contain a certain amount of color as well as turbidity. Table 2 shows some waters located in the south central part of the State with optima consistent with those found by Baylis, and Wagner and Enslow. These waters are more or less turbid with practically no color.

Table 3 gives the figures on the highly colored clear waters. The water used at Hamlet and Lumberton, with comparatively low colors, give optima around 5.5, while the three supplies at Wilming-

TABLE 1

Waters with optimum 5.5

NUMBER OF TEST	TOWN	NATURE OF RAW WATER	ALKALINITY	COLOR	TURBIDITY	pH RAW WATER	OPTIMUM pH
1	Rocky Mount	Tar River	23	20	50	6.4	5.6
2	Rocky Mount	Tar River	21	10	350	6.4	5.6
3	Rocky Mount	Tar River	21	40	80	6.4	5.6
4	Tarboro	Tar River	18	20	50	6.4	5.6
5	Tarboro	Tar River	16	20	300	6.4	5.6
6	Greenville	Tar River	17	30	50	6.4	5.6
7	Greenville	Tar River	19	20	300	6.4	5.6
8	Raleigh	Impounded Creek	17	20	40	6.4	5.6
9	Hickory	Creek	8	10	60	6.2	5.6
10	Salisbury	Yadkin River	18	10	350	6.4	5.6
11	Winston-Salem	Impounded Creek	21	20	100	6.8	5.6
12	Henderson	Impounded Creek	7	0	50	6.4	5.8
13	Wilson	Creek	14	30	40	6.4	5.6
14	Wilmington	Cape Fear River	9	80	200	6.3	4.8
15	Wilmington	Cape Fear River	7	80	20	6.3	5.6
16	Wilmington	Cape Fear River	8	40	150	6.6	5.6
17	Washington	Creek	19	60	60	6.4	5.6
18	Goldsboro	River	7	60	150	6.8	5.6

TABLE 2

High optimum turbid waters

NUMBER OF TEST	TOWN	NATURE OF RAW WATER	ALKALINITY	COLOR	TURBIDITY	pH RAW WATER	OPTIMUM pH
19	Durham	Impounded Creek	21	0	80	6.8	6.6
20	Gastonia	Impounded Creek	21	0	40	7.6	7.0
21	Gastonia	Impounded Creek	20	0	300	7.0	6.6
22	Charlotte	Catawba River	23	0	200	6.8	7.6
23	Concord	Creek	39	0	80	6.6	6.6
24	Wadesboro	Creek	11	0	60	6.6	6.4
25	Lexington	Creek	40	0	60	7.2	7.0

TABLE 3

High colored clear waters

NUMBER OF TEST	TOWN	NATURE OF RAW WATER	ALKALINITY	COLOR	TURBIDITY	pH RAW WATER	OPTIMUM pH
26	Lumberton	Lumber River	6	150	30	6.2	6.3
27	Lumberton	Lumber River	0	150	30	5.4	5.2
28	Hamlet	Impounded Creek	7	70	0	6.4	5.7
29	Wilmington	Northeast River	6	250	30	5.9	4.3
30	Wilmington	Northeast River	9	150	20	6.3	5.0
31	Elizabeth City	Knobs Creek	8	200	20	6.4	4.5
32	Hertford	Perquimans River		500	0	5.6	4.8

ton (northeast river), Hertford and Elizabeth City, with an excessive color, show much lower optima. The first two are located in interior of the State, while the latter three are on the coast.

TABLE 4

NUMBER OF TEST	ALUM	ALKALI	pH	FLOC
	g.p.g.	*p.p.m.*		
1	0.5	0	6.2	None
2	1.0	0	6.0	Poor
3	1.5	0	5.6	Excellent (optimum)
4	2.0	0	5.2	Slow
5	2.5	0	5.0	None

TABLE 5

NUMBER OF TEST	ALUM	ALKALI	pH	FLOC
	g.p.g.	*p.p.m.*		
1	3.5	10	4.8	None
2	3.5	14	5.2	Poor
3	3.5	18	5.4	Excellent
4	3.5	22	5.6	Excellent
5	3.5	28	5.8	Good (slow)
6	3.5	30	6.0	Good (slow)
7	3.5	32	6.0	Poor (very slow)
8	3.5	36	6.4	Very Poor
9	2.0	6	5.2	Poor
10	2.0	8	5.4	Fair
11	2.0	10	5.6	Fair (optimum 2 grains alum)
12	2.0	12	5.7	Fair
13	2.0	14	5.8	Fair
14	2.5	8	5.0	Poor
15	2.5	10	5.2	Poor
16	2.5	12	5.4	Poor
17	2.5	14	5.6	Good
18	2.5	16	5.7	Good
19	2.5	18	5.7	Good
20	2.5	20	5.8	Slow
21	2.5	24	6.2	Slow, fair
22	2.5	28	6.4	Fair, smoky
23	2.5	32	6.6	Fair, smoky
24	2.5	36	6.8	Poor
25	2.5	40	6.8	Poor

The method used for determining optima on these waters, consisted in using the ordinary "jar test" and applying the results

obtained with this to the plant itself. A series of 1 liter jars were used and alum, soda and lime solutions prepared so that each cubic centimeter of alum solution put in a jar of raw water would be the equivalent of $\frac{1}{2}$ grain per gallon, and each cubic centimeter of alkali solution in the same way was equivalent to $\frac{1}{8}$ grain per gallon. In this way any combination of chemicals could be used. The pH was then determined on each jar test, and the jar furnishing a floc most quickly was considered the optimum. In this connection it may be noted that the observation of Clark and Theriault that the quickest forming floc is always eventually the best floc was borne out in these tests.

TABLE 6

NUMBER OF TEST	ALUM	ALKALI	pH	FLOC
	g.p.g.	*p.p.m.*		
1	2.0	0	5.8	None
2	2.0	6	6.0	None
3	2.0	12	6.2	None
4	2.0	16	6.3	Poor
5	2.0	20	6.4	Poor
6	2.0	30	6.6	Excellent
7	1.0	15	6.6	Excellent
8	1.0	10	6.4	Poor

In waters where there was sufficient natural alkalinity to react with the alum, the determination of the optimum is a simple matter, as it is only necessary to run a series with various amounts of alum. Where there is required additional alkalinity the tests were complicated by the two variables. In the latter case a series of jar tests must be made for each quantity of alum, with the amount of alum the same in each jar and added alkali varied. In each case the pH is carried to a point on acid side where no floc forms after hours, and similarly on the alkali side to a point of no floc formation.

Tables 4, 5 and 6 will illustrate a typical set of tests.

In table 4 the alkalinity of the raw water was 21 p.p.m., which was sufficient for the necessary alum. If sufficient alkali had been used to bring pH on no. 5 test to 5.5 an excellent floc was formed. This is the water designated no. 1 in table 1.

The water in table 5 is the one listed in table 3 from Hamlet. It has fairly high color and no turbidity.

Table 6 shows data on the water listed in table 2 as Concord. It will be noted that there is no color and the natural alkalinity is 39 p.p.m.

The tables 4, 5, and 6 will give an idea of how each test was carried out. It is not considered necessary to burden this paper with the mass of figures producing the optima tabulated in tables 1, 2, and 3.

HIGH OPTIMUM WATERS

It is rather difficult to offer explanation of the high optimum waters. The chemical contents do not differ appreciably from those with lower optima. An important fact, however, is that there is quite a difference in the alkali requirements on these waters from that of the 5.5 series. It is generally true that the latter require about 6 parts per million for every grain of alum per gallon. In the case of the waters at Charlotte, Concord, Gastonia, Wadesboro, etc., in table 2, although there is found more than enough natural alkalinity to react with the alum added, it is necessary to add excessive amounts of alkali to get a good floc. In the case of Charlotte the raw water alkalinity was 21 p.p.m. and this should be entirely sufficient for 2 grains per gallon of alum. However, it was necessary to add 30 p.p.m. additional alkalinity to get the best floc. It was not possible to get CO_2 determinations on the various waters, but at Charlotte and Wilmington these are recorded daily and do not show appreciable differences.

HIGHLY COLORED WATER

The highly colored waters show low optima. The excessively highly colored waters at Wilmington, Elizabeth City and Hertford require optima as low as 4.5, while partly colored waters at Hamlet and Lumberton may run as high as 5.6. The water at Wilmington has been especially studied, Mr. Geo. D. Norcom, in charge of the filter plant, having made numerous pH determinations during the last year. This is typical of the highly colored waters, and a low alkalinity treatment was worked out for it by the author in 1916, and is still in use. This treatment (*Engineering Record*, June 2, 1916) consists in adding only enough alkali to give 4 p.p.m. for each grain per gallon of alum, and adding additional alkali in a second basin, the principles involved in the precipitation of colloids prompting this treatment as explained at that time. The Elizabeth City water and that at Hertford act similarly.

A very interesting condition exists at Wilmington. Just below the filtration plant, the Cape Fear river forks forming the main Cape Fear Northeast branch. The main river usually is a low colored, high turbidity water, while the Northeast branch is highly stained from cypress swamps. Up to very recently water has been taken from the Northeast branch, where the tidal changes furnish a clear colored water at times and at others a mixture of this with the main Cape Fear water. The tests on the Wilmington water under table 3 are made on this colored Northeast water and show an optimum of about 4.5. Recently the intake was extended across to main river, and the Wilmington tests under table 1 are made on the new water. Thus we have the main river showing an optimum about 5.5 and its branch fed from Cypress swamps showing the lower optimum.

CONTROLLING THE pH BY ADDING ACID

In the case of the Tar river waters tests 1–7 in table 1, sulphuric acid was used with the results that as good floc was formed using 0.5 grain per gallon alum as were 1.5 grains was required without acid. It was necessary to add 1.5 g.p.g. alum before the optimum of 5.6 was reached and by adding just sufficient sulphuric acid to produce a pH of 5.6 with 0.5 g.p.g. alum similar results were accomplished.

All attempts to cut down the pH of the highly colored waters with sulphuric acid, thus reducing the amount of alum required, were unsuccessful.

COLLOIDAL CLAY AND COLOR AS A REASON FOR VARIABLE OPTIMA

A possible explanation of the variable optima lies in the colloids in the water. Clay in colloidal state has a negative electric charge and color a positive charge. The fairly heavy clay particles have no influence. The whole process of coagulating water has two stages. The first reaction is entirely a chemical one, where definite amounts of alkali combine with definite amounts of aluminum sulphate with the formation of aluminum hydrate. Even with the tests where the pH is too high or too low and no good floc is formed, there is, except when too little alum is used on a highly colored water, a smoky appearance showing the formation of aluminum hydrate. This aluminum hydrate is held in a colloidal state and must be thrown down by physical means. There seems to be required a definite pH

or definite electrical charge to precipitate the positively charged aluminum hydrate and negatively charged coloring matter and clay particles.

VALUE OF pH PLANT CONTROL

Thus far the practical application of the pH determination indicates valuable assistance to the plant operator. Having determined the optimum pH it is only necessary to take samples of water from the mixing chamber and determine the pH. If below the optimum, more alkali should be added and, if above the optimum, alkali is reduced. If supposed optimum is shown and poor floc is forming, it would suggest a change in optimum, and a redetermination of this is made. Our experience so far shows that the optimum does not change frequently. In the case of the Tar river tests (table 1, tests 1 to 3) the first test was made in August after a long dry spell, the second test in October after heavy rains and the third in February during cold weather conditions. In each case the optimum was the same.

Our experience also indicates that coagulation taking place at the optimum pH, gives a heavy, well-defined floc, and that it takes place more rapidly, thus requiring less mixing chamber and coagulation basin retention time. Attention is especially called to the influence of this control of coagulation on mixing chamber design.

CONCLUSIONS

1. The majority of waters in North Carolina coagulate most satisfactorily at an optimum pH of approximately 5.5. Highly colored waters require a much lower optimum, approximately 4.5 pH. Some turbid waters, free from color, have a much higher optimum, varying from 6.5 to 7.5 pH.

2. A technique sufficiently simple for the average small plant operator may be devised for determining hydrogen ion concentration in water purification control.

3. Experience on a number of waters in North Carolina indicates that the pH determinations furnish a valuable assistance in securing more effective and economical results.

4. There is considerable variation in the optimum for various waters and it is necessary that large numbers of waters throughout the country be investigated in this respect, before all facts in regard to pH control may be definitely determined.

DISPOSAL OF WASTES FROM DYEHOUSES AND TEXTILE OPERATIONS[1]

By Albert O. True[2]

Satisfactory and economical methods for the disposal of industrial wastes have been the subject of investigation and experiment for over fifty years. The rapid development of the manfuacturing industries about the middle of the last century, due to the extended application of steam and water power, was accompanied by a corresponding increase in the number and amounts of waste matters. A large percentage of these wastes originate in dyehouses and various textile operations.

A very noticeable pollution of streams has resulted from the direct discharge therein of unpurified waste waters from industrial plants subsequent to the establishment of the factory system.

At first, little effort was made to lessen the pollution of streams by these wastes. This was probably due to the fact that many of the early mills were located on relatively large streams affording water power, and consequently having a volume of flow sufficient to dispose of the wastes by dilution without nuisance; and partly to the failure of the governing authorities to realize the increasing damage to water supplies from these discharges.

Complaints from riparian owners against the use of streams as a medium of waste disposal, and the growing appreciation of the relation of stream pollution to public health and convenience, in time influenced boards of health and commissions governing public water supplies to investigate these conditions with a view to their prevention.

The awakening to the possible evils of uncontrolled stream pollution resulted in the passage, in several states, of legislative acts aimed to prohibit the discharge into state waters of industrial wastes. In some instances, boards and commissions with extensive powers, derived from these acts, undertook to enforce immediate abatement

[1] Presented before the North Carolina Section meeting, November 15, 1923.

[2] Sanitary Engineer, Proximity Mfg. Co., Greensboro, N. C.

of stream pollution. This proved impracticable and unattainable except by destroying the industries concerned. A realization of this fact compelled a more reasonable attitude of public officials toward these problems, and a policy of coöperation rather than coercion has gained ground. Those states which have had to consider stream pollution, only in late years, are profiting by the mistakes resulting from this early legislation.

At first, factory and mill owners were slow to take steps to purify their industrial wastes. Any treatment which might be devised would entail an outlay which, even though relatively moderate, would pay no returns on the investment. As investigation of the subject progressed, the fact was brought out, or at least emphasized, that in some industries considerable quantities of valuable and probably reclaimable products were passing out with the waste waters and therefore were lost. This viewpoint stimulated another line of investigation of the problem, namely, the recovery and utilization of products from waste matters, and consequent increased efficiency in the industry.

The adoption of methods of waste treatment by manufacturers, together with improved methods in the treatment of municipal sewage, has resulted, in many localities, in a considerable improvement of the sanitary condition of streams and rivers. There is still, however, a large field of endeavor in the improvement of conditions due to pollution of streams by industrial wastes.

Many of the works and methods now in use for the treatment of industrial wastes must be considered inefficient. This is often, though not always, due to the use of methods not adapted to local conditions. It would probably be safe to say that success in industrial waste disposal requires more knowledge of local conditions and their intelligent use than any other phase of sanitary engineering.

With the development of comprehensive sewer systems for urban areas, industrial plants availed themselves of the public sewers as a ready means of waste disposal. This tended to cause local nuisances if the wastes from many establishments were discharged into a stream in large quantity at one or several sewer outfalls, instead of being dispersed by discharge in relatively small quantities at each mill. Another complication soon arose in connection with the discharge of trade wastes into public sewers. As works for the treatment of municipal sewage were installed, it was found that industrial waste water had considerable influence on the amount and character of the

sewage to be treated. In some localities this influence, due to the small proportion of industrial waste to total sewage flow, and also to the character of the waste, had no important significance. In other places, however, so serious interference with the physical, chemical and biological functions of sewage treatment plants by these wastes was experienced or anticipated as to necessitate their exclusion from the sanitary sewers.

The successful solution of industrial waste disposal problems, in the opinion of the writer, will require the best and continuous efforts of the chemist, biologist and engineer and the coöperation of the manufacturer. It comprises a field which cannot be standardized. The changes and advances in industrial processes, and the establishment of new industries are being accompanied by changes in the kinds and amounts of wastes to be disposed of, and the appearance of new waste products.

The utilization of waste products and the reclamation of valuable elements from by-product wastes do not appear, for the most part, to offer any considerable probability of profit at the present time. Valuable elements in wash waters are small in amount, as compared with the quantity of water to be handled, and the expense of separation is usually as great or greater than the value of the elements conserved. In addition, there remains the expense of disposal of useless products.

In general, the chief and immediate aim in waste disposal is to devise an economical means of removal of these products without appreciable nuisance. As already stated, local conditions are the chief factors in determining the methods to be devised, the type and arrangement of disposal works, and the degree of purification to be sought.

With reference to the disposal of dyehouse and textile wastes, some observations, of a preliminary nature, have been made by the writer on methods of treatment of waste waters from several cotton mills.

The liquid waste from one of the mills consists largely of wash water resulting from various operations in the dyehouse. Briefly stated, it is a composite consisting of water containing small amounts of indigo dye and sodium sulphate from the blue wash boxes, the water from the white wash boxes containing caustic soda, and the wash water and expended dye liquid from the circulating dyeing machines containing sulphur colors, salt, carbonate of soda and sulphide of soda. It varies in color at irregular intervals, being black,

dark blue and dark brown. It is usually warm and sometimes hot, possibly 100°F. The total flow of this waste is something less than 30,000 gallons per day.

For some years it was disposed of by pumping to soak pits opened in the ground on a hillside near the mill. In time this ground became saturated with the waste and it became necessary to have recourse to a better means of disposal.

A chemical precipitation and a filter plant was then constructed near the mill and about three-eighths of a mile from the creek, and is treating this waste at the present time. It consists, in the main, of a receiving reservoir, a chemical house equipped with arrangements to apply calcium chloride as a precipitant, a series of six concrete sedimentation tanks, a series of sand sludge drying beds and a filtration bed of sand resting on gravel.

The waste is conveyed to the plant by gravity in a sewer pipe which discharges into the receiving and equalizing reservoir, the latter having a capacity of about 21,000 gallons. From there it flows through the chemical house and receives a continuous application of calcium chloride solution amounting to about 230 grains per gallon of waste. It then flows continuously through the six sedimentation tanks in series. The aggregate capacity of these tanks is about three days flow of waste. The discharge from the last precipitation tank occurs at the surface of the liquid, and is received on the filter bed. The latter consists of both coarse and fine grained materials $2\frac{1}{2}$ feet deep, having a superficial area of 2000 square feet, and underlaid with pipe drains. The final effluent is discharged into a channel leading to the creek. Most of the sludge resulting from the precipitation accumulates in the bottom of the first two tanks. About once a week it is pumped out into the sludge filters. After draining and drying the sludge cake is removed by special hand shovels and disposed of by dumping near the plant on unused land.

The cost of installation of this plant was about $10,000. While it effects considerable removal from the waste of substances which discolor the creek, it is relatively expensive to maintain.

At another mill an entirely different procedure is being followed than that in use at the first mill. The location of this mill permits the wastes to be discharged by gravity into a reservoir built with earth embankments on the bank of the creek. From this reservoir, the liquid is pumped through a cast iron discharge main onto a clearing of some 20 acres occupying a side hill adjacent to the creek. Near the

upper side of this clearing the waste is discharged vertically to a height of about 12 feet through a number of openings in the pipe about $\frac{3}{4}$ inch in diameter. This affords a certain amount of aeration as the liquid falls in drops and splashes on the ground. The run-off is conducted by gravity over the hillside, and directed by a system of low dikes which distribute the flow and prevent direct run-off to the creek. Ultimate disposal takes place by seepage, evaporation, oxidation and absorption by plant growth. The arrangement of dikes permits the use of one-half of the dispersion area at a time, thereby permitting the other half a period of rest.

It is noteworthy that this intermittent dosing of vegetation with the dyes has produced an exceptionally heavy and luxuriant growth of grass and weeds on this disposal area.

The aggregate amount of wastes disposed of on the area just referred to is approximately 350,000 gallons per day. While this method of disposal has proved satisfactory for the conditions obtaining at these mills, it would probably be satisfactorily used only where large areas of suitable land were available to which the wastes could be pumped at reasonable expense.

The waste disposed of is a mixture of a blue wash water containing small amounts of indigo, tallow, soda ash and starch; and a dark brown water containing small amounts of basic color dyestuff, acetic acid, starch paste, soda ash, indigo, sulphur dye, sodium sulphite, bichromate of soda and copper sulphate.

The resultant waste, as pumped from the reservoir, varies considerably in quantity and character. At times it is a greyish blue, at others a pale blue and frequently a light brown.

In the summer of 1922, some studies were started on the wastes of these mills, with a view of devising improved methods of treatment and disposal of same. These have been carried on in an experimental manner to date. The information gained so far is more the result of preliminary observation than intensive study.

Most of the experiments have been on purification by chemical precipitation, although some general observations have been made on filtration, without the use of precipitants, to encourage natural bio-chemical oxidation. Past experience seems to indicate that the character of nearly all trades wastes can be improved more or less by methods which provide means of oxidation and encourage bacterial activity. The results of such experiments as have been made with the wastes from these mills indicate, however, that biological

methods of treatment are unlikely to be very successful. The dyehouse wastes have much color in stable solution. These colors have been removed only slightly by filtration. All are high in matters in colloidal solution, which have not been satisfactorily removed by filtration alone. The resulting untreated effluents from the mills are always alkaline, varying from about 500 p.p.m. to 4000 p.p.m. of alkalinity. Liquids so strongly alkaline as these wastes probably inhibit the growth of bacteria, and produce a condition unfavorable to purification by biological agencies.

Experiments have been made testing the use of sulphuric acid, calcium chloride, lime, copperas and aluminum sulphate as precipitants for the various wastes and composites.

Calcium chloride, used alone, has been fairly satisfactory as a precipitant. It appears to give best results with the indigo waters. It is cheap and easily dissolved and applied. It removes a large per cent of colloidal and suspended matters, but leaves a supernatant liquid somewhat high in color. The sludge produced by it dries readily when drained on porous beds, and forms a cake which can be removed easily and cheaply by hand. To be effective, it has had to be applied in relatively large quantities, or about 200 grains per gallon of waste.

Copperas and lime together have produced fairly satisfactory precipitation with some of the wastes, but not with others. Sulphur appeared to interfere with its action by the formation of black, finely divided sulphides.

The best results have been obtained by reducing the alkalinity of the composite waste with sulphuric acid and subsequently coagulating it with alum. Many tests were made to serve as a guide in arriving at the amount of these precipitants for best results. No extended or precise tests have been made, as yet, to determine the degree of purification obtained, but reduction of color, turbidity and total solids have been observed as indices of relative purification. These indicate that with the average composite waste satisfactory results can be obtained by treating the composite with about $\frac{1}{2}$ pound of sulphuric acid and 2 pounds of aluminum sulphate per 1000 gallons of waste, or expressed in other terms, $3\frac{1}{2}$ grains of acid and 14 grains of alum per gallon.

With slight agitation to diffuse the applied chemicals, rapid coagulation usually results. The resulting sludge settles almost completely in less than an hour, and occupies a space of about 0.15 of the total

volume of the waste. The supernatant liquid has been usually clear, free of suspended solids, and of a pale green or yellow color. It has some chemical odor, frequently of hydrogen sulphide, but much less than the untreated liquid. It is stable, usually remains clear, but at times becomes slightly milky on standing. When diluted with five times its volume of clean creek water it largely loses its identity with reference to color and odor.

A small experimental plant has been built capable of treating 2000 gallons of composite waste per day of ten hours. It has been in operation for about two months for five hours each day and treating 1000 gallons of the waste from the earthen reservoir mentioned above.

It consists of a measuring box arranged to deliver the waste at a uniform rate of $3\frac{1}{3}$ gallons per minute, a chemical house for preparing and applying sulphuric acid and alum at a uniform rate, a series of mixing boxes for aerating and mixing the waste with the chemicals, a settling tank to hold five hours flow, having hopper bottoms for sludge storage and two sets of sand filters, one for sludge drying and a second for filtration of the tank effluent. The plant is operated by the continuous flow method.

The settling tank was operated one hundred and thirty hours before any sludge was withdrawn. During all this period a high percentage of settleable solids was removed. There has been no evidence of any putrid decomposition of the sludge. Reductions in color between influent and effluent of settling tank of about 75 per cent and sometimes more have been obtained. Reduction in total solids was from 28 to 60 per cent. The sludge stored in the hoppers of the settling tank was stable and there has been no ebullition of gas or other evidence of bacterial activity. The sludge drawn off from the hoppers of the settling tank by gravity and discharged onto the sludge drying filters had an odor of hydrogen sulphide, but this was noticeable only right at the filter. This sludge is black, drains readily and drys in a few days in favorable weather. No putrefactive odors have been noticed at this plant.

Two of the most important considerations in the treatment of a waste of this character by chemical methods are sludge disposal and effective means of ascertaining the amounts of chemicals needed. At this plant it is the intention to make further investigation of sludge disposal possibilities. Owing to continual, and at times large, changes in the character of the waste and the peculiarities of coagula-

tion, some means of ready chemical control is necessary. It is hoped that the hydrogen ion tests can be used to advantage to control changes in the chemical dosage to obtain the optimum conditions for coagulation.

With the establishment of a satisfactory treatment, it would contribute very materially to the efficient operation of such disposal plants, if the processes in the mills could be standardized to the end of keeping the waste waters more uniform in strength and character. The use, as far as possible, of uniform amounts of water and chemicals for various processes, and the establishment of regular periods for intermittent cleaning operations would tend to produce a waste of uniform strength and character. It is obvious that such a waste can be more efficiently treated than one which exhibits wide and sudden changes in character.

WATER SUPPLY AT THE NEW BERN, N. C., CONFLAGRATION[1]

By F. G. Godfroy[2]

On December 1, 1922, at 8:38 a.m. an alarm of fire was turned in from Box 61. Upon answering this alarm, we found that the entire saw mill, engine room and dry kilns of the Rowland Lumber Company, on Griffith Street, were in flames. The fire had reached such a stage there was no hope of saving any part of the property then involved, so all efforts were directed to prevent the spread of the fire to the planing mills, storage sheds and boiler room.

As soon as the magnitude of the fire was seen all available apparatus in the city was rushed to the scene. This consisted of two American La France pumpers and two hose wagons. Trucks were pressed into service to get hose from the fire stations until all the spare hose was upon the ground.

The Rowland Lumber Company also had a very well equipped department and two 750-gallon Underwriter pumps with a direct suction to the Neuse River. One city truck was connected to the mill supply and one to the city mains.

This fire was finally brought under control, but not until it had totally destroyed all the dry kilns, engine room and power plant, and swept through and destroyed all the docks and the lumber that was piled upon them ready for shipment.

While this fire was at its height, another alarm was turned in from Box 32, corner Queen and Pollock Streets about 1½ miles from the mill. The chief and two of the firemen answered this with autos carrying a couple of hand extinguishers, but this blaze, which was in the roof of a negro house, had been extinguished by a bucket brigade. A few minutes later another alarm was turned in from Box 47 and immediately after that an alarm from Box 42. As soon as possible the Chief had hose loaded and sent one of the trucks to answer this alarm (which was nearly a mile from the scene of the first fire).

[1] Presented before the North Carolina Section Meeting, November 14, 1923.

[2] Superintendent of Water Works, New Bern, N. C.

This last fire was the starting of the conflagration that later caused a loss of over $2,000,000 and laid in ashes 1004 buildings that ran all the way from the smallest negro cabin to the largest warehouses in the city.

When the Department arrived upon the scene of this third fire in the negro section, there were more than three blocks of buildings involved, and a 45-mile gale was blowing from the southwest. It was soon seen that we were in for a hard fight and help was wired for to Kinston and Washington, both of whom responded promptly. Kinston drove their truck through the country, and Washington came through on a special train in record time.

Upon arrival the Washington company were located at the corner of New and George Streets and was a big factor in stopping the spread of the fire in this section. We also dynamited three or four houses in this section. The Kinston company were located at the corner of Broad and Metcalf and were instrumental in stopping the spread of the fire at Metcalf and New and Metcalf and Johnson Streets. At this point several houses were also dynamited. Both of these pumpers were drawing from the city supply and in addition to this the other two pumpers of the New Bern Department were drawing from the mains on the northern edge of the fire. The fire was so situated that direct pumpage from the river was not possible. This made the situation all the harder.

This sketch of the fire is given to show the amount of water that we had to furnish. In addition to these pumpers, there were several places where there were hydrant lines connected and these had to be abandoned later without shutting down the hydrants, due to the rapid spread of the fire. In addition to this there were several hundred openings in the domestic services that were broken off and were wide open in the burned area.

In spite of this we maintained a pressure that was, at its lowest, 20 pounds on a gauge at the City Hall, over a mile from the fire.

I shall endeavor to describe how we did this. This city had recently installed a new water plant at Glenburnie Park, $2\frac{1}{2}$ miles north of the city. This plant is equipped with two 900 g.p.m. electrical-driven 2-stage centrifugal pumps and one 750 g.p.m. 2-stage centrifugal pump driven by a 75 h.p. gasolene motor. There are four wells in this group that have delivered upon test 2100 g.p.m.

We have only one power line from the city limits, but inside the city limits where we have fire hazard, we have three feeders. These

feeders are so arranged that we can shift the outside line to any one of these feeders, through a system of switches on the poles that carry the wires. These circuits are called the Bern Street circuit (which normally supplies the pumping station), the Broad Street circuit which supplies the central part of the city and most of the commercial power, and the Pollock Street circuit which supplies the main business section. Each of these circuits are inter-connected with poles switches of the air break type, single pole, so that they can be closed and the feeders connected to the pumps with a minimum of trouble.

The value of this arrangement was early demonstrated, as the Bern Street feeder was burned down for over two blocks in less than thirty minutes after the third alarm was turned in. The gasolene unit was started and kept running until linemen could make the shift in switches to throw in the Broad Street line. This only lasted for possibly an hour and a half when it was put out of commission by a telephone cable falling across it. The gas unit was started again and the linemen made another shift to the Pollock Street line which was our last hope and which fortunately was undamaged. But with this arrangement we were sending current nearly 5 miles to get to a plant that was less than 3 miles from the source. When the new system was installed, we had suspended operation of a pumping plant in the rear of the City Hall that had a capacity of 750 g.p.m. This was a centrifugal pump single stage and motor driven pump. This plant had been kept in operating condition for emergency use. This unit was started and ran throughout the day and all night, without stopping or giving any trouble. We also had two 600 g.p.m. duplex steam pumps at the electric power plant, that had formerly been used to supply the city with water and were connected with the wells at that location. They had been overhauled and were being used to supply cooling water to the surface condenser of a 1250 kw. turbine. These were also connected to the city mains and gave us an additional 500 g.p.m.

We had also a new station at Glenburnie known as the No. 2 station. This station was under construction at the time. The pump was in place and connected, but the motor was not connected to the line. This was connected in a hurry and this station also gave us valuable assistance.

The Roper Lumber Company had their two Underwriters pumps connected with the City mains, but were blocked off with check valves. As soon as we saw that we were not going to be able to

maintain the service necessary with the equipment we had, we had the Roper Lumber Company remove the checks on these valves, and they started to pump raw river water. This was continued all the balance of the day and far into the night before these pumps were shut down. The Pine Lumber Company also has a 750 g.p.m. Underwriter pump and we did the same thing with this pump.

With the pumps we had in service at this time we were furnishing approximately 5000 g.p.m. and this was only sufficient to supply the four pumpers and the waste from open hydrants and broken connections at a pressure of 20 pounds. But, as we handled the situation, at no time were we without water. Only one pumper had to resort to hand suction pipe to get what water it needed and this was on the side where two pumpers were drafting from one 6-inch main.

As soon as it was possible to get into the area that had been burned, men were sent to shut off the domestic services. They worked all night, and in the meantime three of the pumpers were taken out of service and we were able to shut down the two lumber mills services. We cut these out as soon as possible so that we could work as much as possible of the contaminated water out of the mains and wash out the mains in the northern part of the city. As soon as the last pumper was called in and the pressure was nearly normal, we connected a tank of chlorine gas to the base of the standpipe and put a direct line into the 12-inch main leading from the standpipe, and put 50 pounds of hypochlorite of lime in the top of the standpipe (capacity 160,000 gallon). This was given a few minutes to settle to the bottom of the standpipe and dissolve. Then the pumps were stopped and hydrants were opened in sections of the city that were calculated to get the best results in removing any bad water that might still be in the system.

These hydrants were kept open until the presence of chlorine gas was readily detectable at each hydrant, then this was closed down.

This nearly drained the standpipe. While we were in this shape an alarm of fire came in from the edge of the burned district, and this necessitated some quick work to get the hydrants closed and the pumps started. Fortunately this was a false alarm and no loss resulted from lack of water at this time.

We were much indebted to Mr. E. B. Bain of the Raleigh Water Works for the hypochlorite that they shipped us, and to the State Board of Health who sent Mr. Baity down to help get back to normal. We are indebted to him, because through his valuable assistance we were able to get back to a safe and sanitary water supply in the remarkably short time of forty-eight hours.

ANNUAL REPORT OF THE TREASURER

I submit herewith my report as Treasurer of the American Water Works Association for the year ending March 31, 1924.

The funds of the Association are on deposit with the United States Mortgage and Trust Company at their bank located at 55 Cedar Street, New York, the transfer from the branch located at 73d Street and Broadway having been made when the location of the office was changed to 170 Broadway. The bank was selected in 1921 by vote of the Executive Committee.

RECEIPTS AND DISBURSEMENTS, APRIL 1, 1923 TO MARCH 31, 1924

Receipts		
Balance on hand April 1, 1923	$ 4,151.65	
Received from secretary	22,463.86	
Interest on deposits	190.04	
Interest on investments	497.14	
Total		$27,302.69
Disbursements		
Expended in payment of vouchers aggregating 216 in number and comprising vouchers 1391–1606, both inclusive. (Checks bearing the same numbers as the vouchers have been drawn, with the exception of those vouchers which cover charges made by the bank on check collections, and the amount of these vouchers is set forth separately below)	$22,906.50	
Exchange on checks as charged by bank, omitting charge for March, 1923, which was included in previous annual report, and including charge of $3.55 for March, 1924, for which no voucher has been drawn, and making a deduction of $1.40 from the total of the vouchers drawn due to the vouchers exceeding the actual bank charges by this amount	27.56	
Bank deduction for 7 checks returned for further endorsement	71.90	
		23,005.96
Balance, April 1, 1924		$4,296.73

Cash balance at close of business March 31, 1924 as shown by March statement of the United States Mortgage and Trust Company		$4,767.16	
From this balance there should be deducted for unreturned checks the following:			
No. 1409	$2.30		
No. 1448	0.18		
No. 1512	1.57		
No. 1546	3.96		
No. 1578	1.74		
No. 1579	0.33		
No. 1590	75.00		
No 1592	10.00		
No 1593	18.00		
No 1597	125.00		
No. 1599	232.35		
Total		470.43	
Net bank balance			$4,296.73

The receipt for interest on investments does not include $42.50 which became due on March 15, but which had not been deposited by the end of March. It is to be noted that there is a difference of $94.69 in the cash balance shown by the secretary and that shown by the treasurer. The two balances do not exactly agree due, in general, to the secretary including vouchers which have been drawn by him before the end of March, but which have not reached the treasurer by March 31.

The receipted vouchers have been returned to the secretary. The cancelled checks and deposit slips, with the book of the treasurer, are available for audit.

The permanent fund has not been changed during the year and consists of the following bonds which are in a safe deposit box at the United States Mortgage and Trust Company, 73d Street and Broadway, New York City.

4 $1000 Dominion of Canada 5 per cent	$4,000
1 $1000 U. S. Liberty 2d 4¼ per cent	1,000
2 $1000 U. S. Liberty 3d 4¼ per cent	2,000
2 $1000 U. S. Liberty 4th 4¼ per cent	2,000
3 $1000 U. S. Treasury 4¼ per cent	3,000
Par value of permanent fund	$12,000
Interest on permanent fund	540

The treasurer received no salary, and is under $10,000 bond which has been placed by the Finance Committee.

ANNUAL REPORT OF THE TREASURER OF THE ELECTROLYSIS FUND

I submit herewith my report as treasurer of the American Water Works Association, for the electrolysis fund for the year ending March 31, 1924.

The electrolysis funds are on deposit with the United States Mortgage and Trust Company at their bank located at 55 Cedar Street, New York.

RECEIPTS AND DISBURSEMENTS, APRIL 1, 1923 TO MARCH 31, 1924

Receipts		
Balance on hand April 1, 1923	$1,298.87	
Interest on deposits	25.26	
Total		$1,324.13
Disbursements		
None		
Balance April 1, 1924		$1,324.13

(Signed) WM. W. BRUSH,
Treasurer.

REPORT OF THE FINANCE COMMITTEE FOR FISCAL YEAR ENDING MARCH 31, 1924

Your Finance Committee presents the following report on the financial operations for the fiscal year ending March 31, 1924. The books of the Secretary and Treasurer have been audited and found correct. All vouchers have been examined and verified.

The details of the financial affairs of the Association as set forth in the respective reports of the Secretary and Treasurer are in accordance with their books.

OPERATING INCOME AND EXPENSES

Your Committee has examined and audited the books of the Treasurer and of the Secretary and has found them to be correct and their cash balances to agree. For the reason that there are certain compensating receipts and expenses such as reprints of author's papers, binding cases, etc., representing initial outlays which later are returned, reports of the Secretary and of the Treasurer do not exactly agree, although both are correct.

Your Committee has taken the figure as submitted by the Secretary, eliminating compensating expenses and repayment of same for use in this report.

The financial committee by direction of the executive committee recommeded at the convention held at Detroit last year a budget calling for the expenditure of $23,000.00, which was approved by the convention. This budget was an increase of $4,528.16 over the actual disbursements of the fiscal year 1922-1923. The actual expenses for the past year as shown by the Secretary's report were $21,915.27, while the operating income as shown by the same report was $22,182.91, which makes a net profit from operations of $267.64. At the beginning of the last fiscal year, April 1, 1923, cash balance held was $3,934. 40, and at the close of the year $4,202.04, showing an increase of $267.64.

SUMMARIZED STATEMENT OF ACCOUNTS FOR THE FISCAL YEAR ENDING MARCH 31, 1924

Balance held in bank April 1, 1923	$3,934.40	
Net income from all sources	22,182.91	$26,117.31
Total operating expenses	$21,915.27	
Balance held	4,202.04	$26,117.31

Permanent fund of the Association is invested as follows:

PERMANENT INVESTMENT FUND

4 1000 Dominion of Canada 5 per cent Bonds, due April 1931	$4,000.00
1 1000 United States Second Liberty Bond, 4¼ per cent	1,000.00
2 1000 United States Third Liberty Bonds, 4¼ per cent	2,000.00
2 1000 United States Fourth Liberty Bonds, 4¼ per cent	2,000.00
3 1000 United States Bonds, 4½ per cent, due 1953	3,000.00
Total	$12,000.00

The committee believes that the permanent funds of the Association should be maintained at all times at not less than $12,000.00.

BUDGET ALLOWANCES AND DISBURSEMENTS

Last year's budget total of $23,000.00 was sufficient to cover all needs and all items came within the amount allowed.

The following is a statement of budget allowance and disbursements for the past fiscal year.

	Budget 1923	*Disbursements 1923*
Convention expenses	$1,200	$1,147.74
Office expenses	1,500	1,466.82
Committee expenses	2,250	1,305.92
Section expenses	1,080	887.79
Secretarial expenses	4,000	3,973.33
Salary of editor	1,500	1,500.00
Printing of JOURNAL	10,000	9,998.38
Rent of office	1,080	1,077.50
Insurance	75	42.00
Contingencies	315	315.00
Exchange on checks		27.36
Binding cases		11.93
Electrolysis Committee Reports		2.00
Office equipment		159.50
	$23,000.00	$21,915.27

The items charged against contingencies during the last fiscal year were distributed as follows:

Traveling expenses, Editor, Secretary, and Treasurer	$168.00
Membership campaign	73.87
Dues Fire Chiefs Association	60.00
Red Cross stamps	13.13

EXPENSES FOR THE CURRENT FISCAL YEAR

For the past three years your Committee has recommended a budget larger than the estimated income with the idea of using if necessary the available cash balance to make up a possible deficiency.

Fortunately our Association has had a healthy growth during these years and not only has it been unnecessary to draw on the cash surplus to meet running expenses, but the surplus has actually increased until it amounted to $4,202.04 on April 1, 1924. Our membership has shown a decided increase in the past year and our activities have so increased that your Committee believes that it is warranted in assuming a decided increase in membership this coming year and so feels safe in recommending a substantial increase in the budget and recommends for the year 1924-1925 one totalling $30,000.00.

1. Convention expenses	$1,400.00
2. Office expenses	1,750.00
3. Committee expenses	2,550.00
4. Section expenses	2,000.00
5. Insurance	50.00
6. Secretarial	5,500.00
7. Salary of editor	2,000.00
8. Printing of JOURNAL	13,500.00
9. Rent of office	1,050.00
10. Contingencies	200.00
	$30,000.00

Convention expenses have been increased $200.00 as our expenses at the 1924 convention are liable to be increased materially over last year.

Committee expenses have been increased because the proposed Manual will increase their activities and consequently their expenses.

For years our section meetings have felt the need of proper reporting of their discussions and now that our financial condition is

so much improved your Committee feels that ample funds should be allotted them so that stenographic notes can be taken of their discussion.

By action of the Executive Committee the position of Secretary Emeritus with an annual salary of $1500.00 was created and this accounts for the increase in secretarial expense.

The editing of the JOURNAL now requires not only painstaking effort, but a continually increasing amount of time which the proposed salary of the Editor covers only in part.

Whether the JOURNAL shall be published in six or eight numbers per year is not for your committee to decide, but it is considered proper to provide sufficient funds to meet the latter possibility.

In recommending the above budget your Committee is not actuated by the idea that because the money is available it must be expended, but with the idea that by these expenditures the Association can be made stronger and more beneficial to its members, provide information and discussions which will increase their knowledge and improve their treatment of the varied water works' problems which come before their members for solution.

Your Committee further feels that the sums appropriated for the various items are ample and that by the same careful administration exercised in the past a substantial balance should remain at the end of the 1924-1925 fiscal year.

Your Committee would further recommend that consideration be given to changing the fiscal year so that it would agree with the calendar year.

AVAILABLE RESOURCES FOR THE FISCAL YEAR, 1924-1925

On April 1, 1924, there was a total membership of 1936 divided as follows:

Active	1624
Corporate	147
Associate	157
Honorary	8

This is a total increase of 234 for the year, against 104 for the fiscal year 1922-1923.

Based on the above the income would be as follows:

Total from annual dues	$14,913.00
Estimated initiation fees and dues	2,400.00
Estimated income from advertising and subscriptions	8,500.00
Interest on investment	750.00
Sales of JOURNAL, etc	237.00
Total estimated income	$26,800.00
Cash surplus	4,202.04
	$31,002.04

Your Committee believes this is a conservative estimate of income.

The Treasurer is under bond for $10,000.00 and the Secretary for $2,000.00 in accordance with the order of the Executive Committee and those bonds are in the custody of the Chairman of the Finance Committee.

Your Committee further recommends that the Executive Committee designate those persons whose expenses to this convention are to be paid by the Association. Your Committee also recommends that no expenses properly chargeable to any other budget shall be chargeable to the contingent fund and that all items chargeable to contingent fund for the fiscal year be listed in the next report.

Your Committee would suggest that a vote of thanks be given to the Secretary, J. M. Diven and also to the Treasurer, William W. Brush, for their efforts in behalf of the Association and the manner in which they have taken care of the financial affairs during the past years.

Respectfully submitted,
GEORGE N. SCHOONMAKER,
E. J. NUEBLING,
GEO. C. ANDREWS, *Chairman*,
Finance Committee.

DISCUSSION

STANDARDIZATION OF SERVICES[1]

I have been especially interested in that part of the committee's report which relates to the action of water on lead pipes, for it is a subject to which I have given some study. Investigations of medical scientists indicate that lead poisoning is more frequent than is generally supposed. Most of its causes are connected with industrial processes, but the action of water on lead pipe is still one which needs to be reckoned with. The problem is not as acute, however, as it was fifty or seventy-five years ago, because lead is not used as much for service pipes and in plumbing systems now as then.

The other evening I was looking over an old book in my library, "A Collection of Reports and Opinions of Chemists in Regard to the Use of Lead Pipe for Service Pipe," compiled by the distinguished engineer, James P. Kirkwood, and published in 1859 by Hosford and Company, New York. It was evidently prepared in connection with a study of the new supply, "Nassau water," of the City of Brooklyn, for pasted in front of the book was a copy of the Rules and Regulations adopted by the Board of Water Commissioners of the City of Brooklyn, April 16, 1859. These rules specified the conditions under which the mains might be tapped, in brief as follows:

The service-pipe had to be laid "sufficiently waving to allow of not less than 1 to 1½ feet of extra length and in such manner as to prevent rupture by settlement." Depth, 4 feet in sand and 5 feet in clay. Weights of lead pipe by different sizes were specified. Block tin or zinc pipe might be used instead of lead. Galvanized iron pipe or iron pipe lined with cement might be used by persons specially licensed, provided there was a waving piece of lead pipe 4 feet long between the iron pipe and the main. Plumbers who installed service-pipes were required to be licensed by the Water Commissioners and were required to make "full returns of the ordinary and special uses for which the water was designed to be applied under the permit," together with a description of "all the apparatus and arrangements for using the water," and surveyor's measurements sufficient to locate the service and its connection. To receive a license the plumber had to be a citizen, 21 or more years of age, and

[1] Journal, May, 1924, page 649.

endorsed by two other plumbers as a person "regularly educated to the business." A bond of $1000 was also required. (This is an early example of a plumber's license, but it had to do with water pipes and not drain pipes as at present.)

The book contains opinions on lead by Dr. Thomas Clarke, Professor of Chemistry, Aberdeen University, Scotland, who devised the soap test for hardness and the water softening process which bears his name; by Angus Smith, of Manchester, England, well known for his coal-tar pipe-coating; by B. Silliman, Jr., of Yale; and by E. N. Hosford, of Harvard, both noted chemists. Dozens of opinions are given by chemists, physicians, plumbers, in England and America, the book having over 350 pages. The most elaborate report is that of E. N. Hosford, Rumford Professor of Chemistry at Harvard, who made an elaborate study (38 pages) for the Board of Consulting Physicians appointed to study the action of the Cochituate Water Supply of Boston upon Mineral Substances, dated April 3, 1848.

The conclusions reached by the various scientists quoted were substantially the same as those recorded in the report of the committee now under discussion, namely, that soft waters, colored, swampy waters, and waters containing carbonic acid are especially likely to corrode pipe to such an extent as to put lead into the water in dangerous amounts. Kirkwood emphasized the danger of allowing water to stand in the pipe and approved the custom of letting the water run long enough each morning to change the water in the pipe before using it.

There is another possible source of lead which should not be lost sight of, namely, deposits of lead ore. These exist in the Merrimack Valley, Massachusetts, a notable example being the so-called silver-mine of Newburyport. The writer has occasionally found lead even in waters at the source before coming in contact with lead pipes.

Several years ago samples of tap water in the City of Providence showed a median occurrence of about 0.5 part per million of lead. In order to be on the safe side and protect the consumers against lead, calcium hydrate was added to the filtered water to neutralize the carbonic acid. The result of this has been to reduce corrosion to such an extent that the median amount of lead in the water is now about 0.05 part per million, while most samples contain none.

There seems to be a growing tendency to pay attention to lead in water and to reduce the permissible amount. Whereas ten or twenty years ago the writer would have placed the limit as 0.5 or 0.3 part per million, he would now place it as low as 0.1 part per million.

The problem of choosing the best material for serving as service pipe seems bound to increase in importance. As a rule, plumbers take little note of the character of the water, not realizing that there is a complementary relation between the character of the water and the character of the pipes conveying it. The use of chemicals in water is becoming so general that the problem will have to be studied in the future with increasing care.

G. C. WHIPPLE.[2]

STREAM GAGING IN NORTH CAROLINA[3]

The continuous measurement of the amount of water flowing in the streams of the state is of great importance. Water power developments and municipal water supplies are based upon the knowledge of stream flow thus obtained. Moreover, the amount of sewage or trade wastes which may safely be discharged into the streams without menace to the public health or creation of nuisances depends directly upon the quantity of water flowing. Isolated measurements are not sufficient for these purposes. The daily stream flow for years is required, covering periods of extreme flood and extreme drought. The longer the record the more valuable it becomes.

The number of gaging stations maintained on streams in North Carolina has increased from 10, in 1920 when the Water Resources Division of the North Carolina Geological and Economic Survey was established, to 46 at present, as shown below:

1920 (June)	10
1920 (December)	17
1921	28
1922	33
1923	46

The locations of the present gaging stations are shown in table 1. During the year two stations have been discontinued. That at Donnaha on the Yadkin River was found to have produced erroneous data since 1917, due to improper recording by the local observer. Since there are excellent stations now on the river, both above and

[2] Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.

[3] Discussion of paper by W. E. Hall and C. C. Covert before the North Carolina Section meeting, November 14, 1923.

TABLE 1

Gaging stations maintained jointly by United States and North Carolina Geological Surveys

Tennessee Basin	
Hiwassee River, at	Murphy, N. C.
Hiwassee River, at	Reliance, Tenn.
Nottely River, at	Ranger, N. C.
Valley River, at	Tomotla, N. C.
Shooting Creek, near	Hayesville, N. C.
Little Tennessee River, at	McGhee, Tenn.
Little Tennessee River, at	Judson, N. C.
Little Tennessee River, at	Franklin, N. C.
Cheoah River, near	Johnson, N. C.
Tuckasegee River, at	Bryson, N. C.
Tuckasegee River, at	East LaPort, N. C.
Oconalufty River, at	Cherokee, N. C.
Cullasaja River, at	Cullasaja, N. C.
French Broad River, at	Dandridge, N. C.
French Broad River, at	Oldtown (near Newport), Tenn.
French Broad River, at	Redmond, N. C.
French Broad River, at	Asheville, N. C.
French Broad River, at	Blantyre, N. C.
Pigeon River, at	Newport, Tenn.
Pigeon River, near	Crabtree, N. C.
Little Pigeon, at	Sevierville, Tenn.
Swannoaoa River, at	Biltmore, N. C.
Davidson River, near	Brevard, N. C.
Nolichucky River, near	Greenville, Tenn.
North Tow River, at	Spruce Pine, N. C.
Watauga River, near	Elizabethton, Tenn.
Watauga River, near	Butler, Tenn.
New River	Va.
Atlantic drainage	
Roanoke River, at	Old Gaston, N. C.
Roanoke River, at	Bugs Island Va.
Roanoke River, at	Roanoke, Va.
Cape Fear River, at	Fayetteville, N. C.*
Cape Fear River, near	Lillington, N. C.
Morgan Creek, near	Chapel Hill, N. C.
Yadkin River, at	High Rock, N. C.
Yadkin River at,	Salisbury, N. C.
Yadkin River, at	North Wilkesboro, N. C.
Deep River, at	Ramseur, N. C.†

*Abandoned September, 1923.

† Established, November, 1923.

TABLE 1—*Continued*

Deep River, near	High Point, N. C.
Fisher River, near	Dobson, N. C.
Santee River, at	Ferguson, S. C.
Linville River, at	Branch, N. C.
Chattanooga River, near	Tallulah Falls, Ga.
Dan River, near	Pine Hall, N. C. (Stokes Co.)
Dan Creek, near	Gastonia, N. C.
Moccasin Creek, near	Zebulon, N. C.
Some stations are to be added soon, such as	
Mills River, near	Mills River, N. C.

The Lillington station is used to replace Cape Fear River at Fayetteville which is not satisfactory. Roanoke River at Bugs Island, Va., will also probably be discontinued soon.

The above list shows 46 active stations on North Carolina streams at present.

below Donnaha, ample records of the flow of the river are being obtained. The station at Fayetteville was re-established during the fall of 1922. Attempts to rate it failed, due to the locks below influencing the control. Accordingly the station was discontinued in September and a station established at Lillington to replace it.

The stream gaging work has continued to be carried on in co-operation with the United States Geological Survey. This organization has a highly trained corps of engineers whose entire time is devoted to stream gaging work. Accordingly, they can carry on this work much more expertly and economically than any local state organization. The State Survey turns over a large portion of its stream gaging funds to the United States Geological Survey, which performs most of the stream gaging work and compiles and publishes the data. The State Survey indicates where new stations are to be located and, in general, exercises a constant and close inspection over all stream gaging carried on in the state. As the District Office of the United States Geological Survey is located at Asheville, the State Survey forces frequently make stream gaging measurements on streams in the Eastern Piedmont part of the state both to save expense and to obtain flood and minimum discharges which often occur only for a day or two, and thus could not be obtained by the engineers from the Asheville office.

That the stream gaging work is of direct benefit to engineers and others in the state is well exemplified by the many requests for

data of this sort. During the past year 35 requests for stream flow data have been made to the Chapel Hill office and 23 requests to the Asheville office. The majority of these requests have been for use on water power projects, though many have also related to municipal water supply developments. These requests are in addition to the very large number of engineers who regularly get their data on stream flow from the publications of the United States Geological Survey, where all the stream flow records in the state are published. These publications give only monthly and daily average flow for each single year. Moreover, these publications frequently are not issued until two or three years after the data to which they apply have been collected. Thus at present the latest bulletin on stream flow issued by the United States Geological Survey is for 1920.

Another instance of the value of the records of stream flow collected and analyzed by the Survey is evidenced by coöperation with the State Highway Commission. Before final acceptance of designs for large new bridges, it has become the custom for the Commission's engineers to consult with the Survey's Hydraulic Engineer as to the necessary waterway to allow under the bridge, the magnitude of probable floods, and the velocities to be expected in these. Thus, in the proposed new bridge across the Cape Fear River, near Elizabethtown, it was possible to save some $100,000 over the original design for the bridge after consultation with the Survey's Hydraulic Engineer made clear what area of waterway would suffice and yet not produce excessive velocities. Similar conferences were held in connection with the design of the new bridges across the Yadkin River. The Highway Commission, in turn, has coöperated with the Survey by making free of charge certain photostats which could not be obtained elsewhere in the state.

Two new automatic gaging stations have been established during the year, one at Ramseur in connection with the Deep River investigation, and one at Morgan Creek near Chapel Hill. The Roanoke Power Company has arranged to pay $1500 toward the establishment of an additional automatic station, of the most approved pattern, at Old Gaston. The establishment of new gaging stations on streams already developed is greatly limited owing to the necessity for automatic gages on such streams. The cost of this kind of installation varies from $600 to $1500 and can be made, with present funds, only when most of the expense of installation is borne by private interests. Additional stream gaging funds are needed for the establishment of automatic stations by the Survey.

Isolated stream gagings have been made by the Survey's engineers for a number of private interests. Requests for this kind of work are met whenever practicable, and the persons making it are charged the usual commercial rate for such services plus expenses. Generally gagings of this sort are requested by individuals wishing to develop some small stream for power, or fishing, or water supply purposes. They wish the Survey to do the measuring of stream flow because of its accurate methods and from the fact that its opinion on the adequacy of stream flow is valued.

Notwithstanding the continued increase in the number of gaging stations in the State (North Carolina now has more gaging stations in operation than all the other South Atlantic States together), many more such stations are urgently needed if the necessary data for new power developments and municipal water supplies are to be collected. The need for stream flow data from small streams likely to be used for municipal water supplies is especially pressing. Municipalities in the state have spent hundreds of thousands of dollars unnecessarily on account of inadequate estimates of stream flow for water supply purposes. Additional funds are needed to be spent solely on stream gaging studies in connection with possible water supplies.

Work has continued during the past six months upon the preparation of a stream flow bulletin for North Carolina, revising Bulletin 20 of the Survey, and bringing it up to date. It is expected that the new Bulletin will be ready to go to press in the spring. When issued it will be the most comprehensive publication on stream flow ever issued by any eastern state. It will show by means of diagrams the weekly flow at every gaging station ever maintained in the state, for the period of record, and also the per cent of time during which such stream flows occur in the average and minimum years. It will present also the usual tables of monthly, mean maximum and minimum stream flow on each stream for each year of the period of record. Many of the engineers of the state are eagerly awaiting the publication of this Bulletin, which will undoubtedly be of great value in enabling proper developments to be made of the water resources of the state. The Bulletin will follow in general the scheme recommended by an expert committee of the United Engineering Societies.

The amount of work expended in preparing this Bulletin may be appreciated when it is recollected that there are 46 gaging stations in the state, that some of them have been in operation for 25 years, and

that each week for the entire period of record has been tabulated and plotted, both in order of its occurrence each year and also in order of magnitude for each year. The tables and diagrams have been so arranged that hereafter annual additions may be computed quickly and the record be brought up to date easily and cheaply. It is intended to have the data complete through 1923 when the Bulletin is issued ; then to issue annual additions each year thereafter, and every ten years to issue a revision of the entire Bulletin.

THORNDIKE SAVILLE.[4]

ERRATUM

JOURNAL, May, 1924, page 717, note on "Hydrogen-ion Tests" by Frank E. Hale. In tenth line from the bottom of the page, "1 cc." should read "16 cc."

[4] Associate Professor, Hydraulics and Sanitary Engineering, University of North Carolina, Chapel Hill, N. C. Hydraulic Engineer, North Carolina Geological and Economic Survey.

SOCIETY AFFAIRS

CANADIAN SECTION

The fourth annual meeting of the Canadian Section was held in the Royal Connaught Hotel, Hamilton, Ontario, on February 27, 28, and 29, 1924. The meeting was a most successful one and five papers were presented by members of the Association, as follows:

Development of Water Purification, By Geo. W. Fuller.

Relative Economy of Standby Oil Engines, By W. S. Lea, Consulting Engineer, Montreal, Que.

Some Water Treatment Problems,[1] By A. V. Delaporte, Chemist in Charge, Experimental Station, Provincial Board of Health, Toronto.

Water Works Distribution Systems, By W. E. MacDonald, Water Works Engineer, Ottawa.

Premoulded Reinforced Concrete Pipe for Water Works Intakes, by W. C. Chace, of the Canada Lock Joint Pipe, Ltd., Toronto.

A banquet was held on Wednesday evening, at which the Mayor, members of the Board of Control and prominent civic officials were present, and Mr. Geo. W. Fuller, President of the American Water Works Association, delivered an interesting address on "Water Purification." This paper was closely followed and enjoyed by everyone present and it was broadcasted by radio for the benefit of those who were not in attendance.

After registration on the morning of the first day, the Convention opened at noon with an informal luncheon, and Mr. F. A. Dallyn, Chairman of the Canadian Section, welcomed the 150 delegates, members of the Manufacturers' Association and guests to the Convention.

On Thursday afternoon, the delegates visited the Beach Pumping Plant, as the guests of the civic officials, where modern steam turbine aud motor driven centrifugal pumps were shown working alongside the old beam engine units erected in 1859.

A most interesting display of water works equipment and materials used by water works plants was shown by the Canadian

[1] Journal, May, 1924, page 605.

Water Works Exhibitors Association. There were 36 booths in the exhibit. The desire of the members to see and investigate the commodities was clearly marked, and there is no doubt that this exhibit contributed to the success of the meeting.

At the business meeting, the annual election of officers took place, and the following gentlemen were chosen for the various positions: Chairman, Norman R. Wilson, Water Works Superintendent, Brantford, Ont.; Vice-chairman and Secretary-Treasurer, C. D. Brown, Manager, Walkerville Water Co., Walkerville.; Trustees, James Meadows, Superintendent Montreal Water and Power Company, Montreal, Que.; R. L. Starr, Water Works Superintendent Orillia, Ont., and D. M. Hanna, Water Works Superintendent, Windsor.

Subsequently Mr. Brown resigned as Secretary-Treasurer, and the Executive Committee appointed Mr. A. U. Sanderson, Superintendent, Filtration Plant, Toronto, to the position.

Montreal was selected as the place of the next annual meeting, after invitations were presented from Montreal, Quebec, Ottawa, Windsor and Peterborough.

Mr. C. D. Brown was chosen to represent the Section on the Nominating Committee of the Parent Association for the election of District Trustees, and the following members were elected as the Nominating Committee of the Canadian Section for the ensuing year: R. L. Dobbin, Peterborough, Alex. Milne, St. Catherines, W. E. MacDonald, Ottawa.

The presentation of papers, together with the discussions that followed occupied the time of the members for the remainder of the session, with the exception of one evening, when a smoker was held in the Hotel Connaught and the entertainment provided was enjoyed by all the delegates.

ILLINOIS SECTION

The sixteenth annual meeting of the Illinois Section was held on Wednesday and Thursday, March 19–20, 1924.

M. S. Ketcham, Dean of the College of Engineering, welcomed the members of the association and spoke of the interest of the University in their affairs. H. F. Ferguson spoke of the filtration plant operators conference which had been held during the two preceding days and also presented details giving data of the construction and operation

of water treatment plants in Illinois. In a discussion on filter sands led by Paul Hansen the sizes of sieves and the advisability of specifying effective sizes and uniformity coefficients of sands were discussed. C. W. Parsons presented a paper on Water Works and Fire Protection of Small Municipalities[2] suggesting substantial storage capacity, duplicating of pumps and mains, use of mains larger than 4 inches, and use of hydrants in sufficient number and of sufficient size.

At the Wednesday evening session W. W. DeBerard gave views of engineering affairs as seen by an editor, citing many notable and interesting events. M. M. Leighton[3] spoke of the various water bearing strata in the State, the relation of water reservoir projects to geologic data, and information available from the State Geological Survey Division.

The officers elected for the coming year are: Chairman, A. M. Buswell, Chief State Water Survey Division; Vice-Chairman, L. R. Howson, of Alvord, Burdick, & Howson; Trustee, C. M. Roos, Secretary & Superintendent, Cairo Water Co.; Treasurer, H. E. Keeler.

Other officers are W. R. Gelston and W. E. Lautz, Trustees, and G. C. Habermeyer, Secretary.

W. W. DeBerard moved that a committee be appointed by the chairman of the section to represent the Water Works Association, Board of Health, Water Survey, and University to consider ways and means of coördinating filter plant operators conferences and Illinois Section activities. The motion was seconded and carried.

One of the two boxing matches scheduled was by members of the University of Illinois team and the other, the funniest a member had seen in a thousand years was by Mutt and Jeff (Greenfield and Swearingen.)

At the Thursday morning session W. B. Bushnell spoke of over chlorination for the control of tastes in the Champaign and Urbana Water Company supply and similar experiences at other plants were spoken of in discussion. W. U. Gallaher pointed out that alum floc is of variable composition and is probably not aluminum hydroxide. E. M. Partridge presented a very interesting paper on Boiler Compounds giving some interesting information on the preparation of boiler compounds which hitherto has not been presented to the general public. Wm. E. Stanley presented data collected by E. E.

[2]This Journal, page 781.
[3]This Journal, page 770.

Ruthrauff, chief operator of the Decatur filtration plant, showing that during the past year, since the new reservoir of about six billion gallons capacity has been in use the turbidity of the raw water has been much less and the color somewhat higher than previously. The paper on Observation of Purification-Plant Designs by S. T. Barker was read by M. LeBosquet. The new proposed bacteriological standards for drinking water would probably be more lenient in the long run than the present standards, according to the data in the State Water Survey files, presented by A. M. Buswell and R. A. Shive.

During the Thursday afternoon session G. C. Habermeyer[4] spoke of decrease in yield of wells due to reaction of waters and gave methods of measuring yields and water levels used by the State Water Survey Division. F. G. Gordon[5] spoke on Cast Iron Pipe Prices giving prices for many years and various months in the year which seemed to disprove the fact that any considerable sum has been saved by buying pipes during winter months. John W. Mabbs, President of Mabbs Hydraulic Packing Company, spoke on packing and the effect of braided rawhide for pump packing.

The attendance was about 80, including 36 members and representatives of the associate members of this section.

[4] This Journal, page 840.
[5] This Journal, page 761.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Chemical Treatment of Water Supply in Active Warfare and the Application of the Methods to Water Supply in Country Districts. M. J. HOLMES. Health, Commonwealth of Australia, 1: 2, 43, February, 1923. Chlorination effected by hand in bulk or by mechanical means; as water was taken from stream, well, etc. under control of trained water man; by mobile sterilizer and stationary sterilizing plants.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Prevention of Algae in Storage Tanks. ALFRED ADAMS. Public Health, 36: 5, 128, February, 1923. Trouble from algae in 40,000 gallon open water tank eliminated by weekly dose of one part per million of chlorine.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Rivers Pollution. C. P. JEPSON. Surveyor, 64: 1662, 387, November 23, 1923. History of river pollution legislation in Great Britain since 1865. Trade depression and use of unemployed on public works has brought the rivers back to pre-war condition.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Treatment of Feed Water. 1923, Report of Prime Movers Committee, National Electric Light Association, Part B, 171. Effect of various water treating systems on boiler operation. Deactivation and deaeration of water by mechanical apparatus, treatment by permutit system of softening by zeolites, tests with Hagen De-Concentrator, feed water heaters, chemical treatment and evaporators described. Table gives summary of data from 36 companies operating equipment ranging from 3,000 to 34,000 square feet of boiler heating surface.—*A. W. Blohm.*

Power House Ventilation. 1923, Report of Prime Movers Committee, National Electric Light Association, Part B, 349. Under most favorable conditions, in boiler room, 12 pounds air are required per pound of coal consumed, or plant using 50 tons coal per hour would require 600 tons air per hour or 250,000 cubic feet per minute at average temperatures. Plant must be designed to replace air lost by combustion and through stack, without causing fogs in turbine rooms, collection of moisture, retaining heat in winter and releasing it in summer.—*A. W. Blohm.*

Operating Code Manual. 1923, Report of Prime Movers Committee, National Electric Light Association, Part B, 367. Revised rules covering general operation of stoker fired boilers. Revisions made to allow rules to fit general case instead of specific in all cases where this was deemed feasible.—*A. W. Blohm.*

The Precipitate from Partially Alkalinized Alum Solutions. L. B. Miller. Pub. Health Reports, **38**: 35, 1995, August 31, 1923. Study made of composition of precipitate formed at different pH values by addition of sodium hydroxide to alum solutions. Certain precautions to be adopted in analytical determination of aluminum are stated, and reason for these given. Theoretical and experimental study of solubility of aluminum precipitate at different pH values was made, and certain conclusions drawn therefrom. Results are compared with those obtained, under varying laboratory and commercial conditions by other workers.—*Aug. G. Nolte.*

Sanitation of Tourist Camps. Pub. Health Reports, **38**: 35, 2016, August 31, 1923. Specific regulations made by State Board of Health of Minnesota are given regarding water supply, toilets, refuse disposal, and camp sites for tourists. County Health Officer best individual to assume responsibility for sanitation of all tourist camps in county.—*Aug. G. Nolte.*

Iodine Administration in Prophylaxis of Endemic Goiter. Robert Olesen. Pub. Health Reports, **39**: 2, 45, January 11, 1924. Most favored method at present time is administration of chocolate tablet containing 10 mgm. iodine in form of organic acid. Preventive should be used regardless of evidence of thyroid enlargement. Use of iodized table salt holds considerable promise as efficient means of preventing endemic goiter, but difficulties of gauging dosage accurately are a handicap. Wholesale iodization of municipal water supply may be cited as ingenious method, in need of further appraisal before definite verdict as to its efficiency can be given. Many references cited.—*Aug. G. Nolte.*

Drinking Water Systems. H. J. Macintire. Power, **59**: 7, 254, February 12, 1924. In first class offices and hotels, use of cold drinking water on tap is becoming common. Water usually cooled to 45°F. by means of Bandalot cooler. Flow through system must be such that even when maximum demand occurs at fountains, there must be water flowing through return line to tank. To reduce pumping work, circuits are usually limited in length to 2000 feet. Water velocities in pipes limited to maximum of 200 feet per min. Consumption is variable, depending upon temperature and upon working conditions of consumer. Hotels and Office Buildings, with outlet in each room, designed on basis of one gallon per person per day. Store and Office Buildings, with outlets in isolated places, one-half pint per min. per fountain. In factories, one-half gallon per person per hour and in offices, one-quarter gallon per person per hour. Number of fountains or outlets is variable. Good practice allows one fountain per 50-100 operators. System should be well insulated. Illustrated.—*Aug. G. Nolte.*

Furnaces for Burning Small Anthracites. A. R. Mumford. Power, 59: 8, 284, February 19, 1924. Progress of combustion studied in furnace of water-tube boiler fired by two Coxe chain-grate stokers. Boiler was a four-drum Edgemoor water-tube boiler, 29 and 30 tubes wide, and 16 tubes high, containing 10,000 square feet of heating surface. Gases crossed the tubes three times in path through boiler, which was baffled by ordinary Edge Moor type baffles. Beneath stoker grate were four separate air chambers, to which air was supplied through three windboxes from a main air duct; in the studies, grates were considered to be divided into four sections, one over each air chamber. Investigation divided into five parts; (1) combustion conditions during normal operation; (2) effect on combustion of raising front arch; (3) effect of air introduced through jets under pressure; (4) effect of steam jets at rear of furnace, introduced to stimulate a rear arch; (5) effect on combustion of a rear arch installed in a furnace with a low front arch. Results of the investigation are discussed and illustrated by diagrams.—*Aug. G. Nolte.*

Testing the Effectiveness of Bearing Lubrication with an Electrical Circuit. W. V. Fitzgerald. Power, 59: 8, 298, February 19, 1924. A brush, placed in contact with a rotating shaft was connected to one binding post of ordinary electric doorbell; other post connected to lower part of bearing pedestal, with two dry cells and switch interposed in line. As oil is fairly good insulator a thin film of it will break a contact such as is outlined above. Purpose of oil in a bearing is to reduce friction and wear to a minimum by placing between metallic surfaces a film of oil. If this film is complete, and no metallic contact occurs, electrical circuit should remain open as long as shaft is revolving. Problem was to decide between a heavy and a light oil for best lubrication for particular job. Each oil was tried in bearing with shaft rotating at normal operating speed and switch closed; test with heavy oil rang the bell spasmodically at considerable intervals; test with light oil under same conditions did not cause bell to ring. Showed that heavy oil did not maintain constant film, while light oil did. Illustrated.—*Aug. G. Nolte.*

Alternating-Current Versus Direct-Current Motors for Stoker Drive. W. E. Douglas and H. H. Bates. Power, 58: 1, 8, July 3, 1923. In general, alternating-current motor has in its favor fact that no converting apparatus is required; except that of the brush-shifting motor, commutators in all cases are eliminated. While alternating-current motors comprise the larger proportion of such drives, direct-current motor has been used with more efficient results on many installations. Where direct-current is available without resorting to special converting apparatus, direct-current shunt-wound motor, with all field control, is best suited for stoker service.—*Aug. G. Nolte.*

Loss of Head in Valves and Pipes. Power, 58: 2, 74, July 10, 1923. Tests were made at Univ. of Wisconsin on valves and pipes from ½ to 12 inches in diameter. Results obtained described in Engineering Bulletin No. 1, Vol. 9. Conclusions therein summarized are given.—*Aug. G. Nolte.*

The Determination of Boiler Efficiency. H. B. Jones. Power, 58: 3, 88, July 17, 1923. Careful scientific analysis is made of errors that arise in determining boiler efficiency.—*Aug. G. Nolte.*

Coal Storage at Detroit Water-Works. Power 58: 4, 133, July 24, 1923. Coal is delivered by water. 25,000-ton shed erected to receive coal, and canal dug to Detroit River, to admit barges. Unloading by clamshell buckets and crane, into hopper with reciprocating feeder, delivering to 30-inch double-roll crusher. 24-inch inclined belt conveyor passes over integrating weightometer, and, at entrance to storage building, delivers coal to 24-inch horizontal belt, which distributes it along south wall by means of automatic self-propelling and reversing tripper. Coal is stored to depth of 20 feet and is leveled up or reclaimed by means of drag scrapers. Further details of the coal-and-ash-handling systems are given.—*Aug. G. Nolte.*

Oil Engine Operating Costs. Power, 58: 4, 140, July 24, 1923. High generating costs in small central stations, due to increased labor and coal prices, solved by Holstein Service Co., of Holstein, Iowa, by installation of two Diesel oil engines, of 165 and 180-horse power, respectively. Average kilowatt-hour output, per gallon of fuel oil, during 1922, was 9.44. Total average cost per kilowatt-hour for 581,590 kilowatt-hours generated, was $0.015.—*Aug. G. Nolte.*

Corrosion by Acid Water. D. H. Jackson. Power, 58: 6, 217, August 7, 1923. Water ordinarily called "acid" is one that will give an acid reaction with an indicator such as methyl orange. Even though most natural waters are on alkaline side of neutrality, they all have, although to a very small degree, hydrogen ions, which give to water power to dissolve iron. Best way of expressing acidity is in terms of hydrogen ions. Iron is soluble in water in proportion to the amount of hydrogen ions present. Corrosion of iron in average neutral, or slightly alkaline, natural water is very small and would automatically stop, were it not for dissolved oxygen present. This unites with the hydrogen liberated by iron-solution process and prevents polarization of the-iron. Also reacts with dissolved iron and precipitates it as iron oxide. Best and safest method of preventing corrosion is removal of dissolved oxygen.—*Aug. G. Nolte.*

Zinc in Boilers. F. M. Gibson. Power, 58: 6, 234, August 7, 1923. A number of statements made, regarding use of zinc in boilers for prevention of scale and corrosion, by subcommittee on Care of Steam Boilers, etc., of the A. S. M. E.—*Aug. G. Nolte.*

Submerged Orifices for Uniform Control of Chemical Feed. Power, 58: 7, 244, August 14, 1923. The Graver Corporation, of East Chicago, Ind., has replaced the system of weirs formerly used for control of the chemical feed in proportion to quantity of water entering a continuous water softener, by a divided flow system employing submerged orifices.—*Aug. G. Nolte.*

Auxiliary Equipment for Blast and Ventilating Fans. C. L. Hubbard. Power, 59: 9, 318, February 26, 1924. Various data on the installation and operation of fans are given. The following subjects are discussed: foundations and supports; miscellaneous fan and motor noises; fan drives (steam engine, steam turbine, electric motor, line shafting); and fan control.—*Aug. G. Nolte.*

Oil Engines Practical even if Process Steam be Needed. J. S. Le Clercq. Power, **59**: 9, 322, February 26, 1924. The Dallas Oil and Refining Co., by using Diesel for power and boilers for process steam, have obtained results that show attractive saving in power costs.—*Aug. G. Nolte.*

Burning Small Sizes of Anthracite. A. A. Cary. Power, **59**: 9, 326, February 26, 1924. Extract of discussion before Metropolitan Section, American Society Mechanical Engineers, January 15, 1924, at New York City. Firing methods for bituminous and anthracite coals are given, and progress of combustion of anthracite coal on stokers, discussed.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, **59**: 9, 342, February 26, 1924. Questions are asked and answers are given on the following subjects. Evidence of Low Piston; Theoretical Power Obtainable from Pound of Coal; Turbo-Alternating-Current Generators in Parallel; Size of Exciter for Alternator; Theoretical Height of Raising Water with Steam Pump; Setting Valves of Single-Valve Automatic Engine; Stuck Piston Ring of Oil Engine; Apparent and Actual Cutoffs; Rattling of Corliss Valves.—*Aug. G. Nolte.*

Fusing Potential Transformers. C. M. King. Power, **58**: 8, 283, August 21, 1923.—*Aug. G. Nolte.*

Drum Suspension for Boilers. J. B. Crane. Power, **58**: 8, 284, August 21, 1923. Various methods of supporting boiler drums are illustrated and discussed.—*Aug. G. Nolte.*

Test of Diesel Fuel Consumption. W. B. Gregory. Power, **58**: 8, 285, August 21, 1923. Fuel guarantees of engine builders were met in every instance, while in every run but one, there was good safe margin between performance and guarantee. At a little more than full load, both engines tested used 0.43 pound fuel oil per brake horsepower per hour.—*Aug. G. Nolte.*

Writing Pipe Specifications. H. E. Collins. Power, **58**: 8, 287, August 21, 1923. To assist those responsible for the preparation of piping specifications, author submits a number of valuable ideas for their guidance.—*Aug. G. Nolte.*

Testing Jet Condensers. L. Long. Power, **58**: 8, 293, August 21, 1923. Various means of locating faults are described in a direct practical manner.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, **58**: 8, 308, August 21, 1923. Questions are asked and answers given on following subjects: Breakage of Firebox Staybolts; Temperature of Water Cooled by Ice; Grounding the Neutral of Alternating-Current Generators; Extraordinary Stresses Induced by Rupture; Cleaning Grease from Gage Glasses; Temperature in Coils Supplied by Steam Through Reducing Valve; Packing Joint at End of Through Stay; Strength of Diagonal Joint.—*Aug. G. Nolte.*

Checking the Operation of Hydro-Electric Units. Ralph Brown. Power, 59: 10, 361, March 4, 1924. Convenient method for checking performance of a hydro-electric unit is given; probable causes for reduction in output are cited. Decrease to about 95 per cent of normal output generally indicates advisability of a thorough overhauling—*Aug. G. Nolte.*

Operation and Care of Drum-Type Manual Controllers for Motors. H. D. James. Power, 59: 10, 368, March 4, 1924.—*Aug. G. Nolte.*

Calculating the Amount of Air Liberated in Barometric Condensers. C. M. Reed. Power, 59: 10, 370, March 4, 1924. Method is presented for estimating vacuum-pump capacity required by barometric condensers and measuring air leakage into condenser installations, with numerous curves for making the necessary calculations graphically.—*Aug. G. Nolte.*

High-Head Penstock Failure Found Due to Bad Steel. Power, 59: 10, 373, March 4, 1924.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, 59: 10, 382, March 4, 1924. Questions are asked and answers given on following subjects: Loss of Heat in Chimney Gases; Treating Overheated Low-Pressure Crankpin; Overloaded Motor;Gasket for Leaky Ground Joint of Cylinder Head; Cutting Snap Rings; Deposit from Cylinder Oil when Using Superheated Steam; Receiver Pressure below Pressure of Atmosphere; Approximate tests of Engine Alignment; Action of Receiverless Compound Engine.—*Aug. G. Nolte.*

The Steam Accumulator and its Application. Power, 58: 9, 322, August 28, 1923. The practical application of using large mass of hot water to store up energy of excess steam at pressures considerably above atmospheric is recent European development. Illustrated article describes the construction of high-pressure accumulator; shows how weights, capacities, etc., are figured; and outlines a few of many possible applications.—*Aug. G. Nolte.*

Care of the Venturi Meter. D. C. Brown. Power, 58: 9, 326, August 28, 1923. Meters should be taken out of service and cleaned at periodic intervals depending on character of service. Where installation is used for measurement of hot boiler-feed water containing scale-forming salts, accumulated deposits in throat section of tube cause increasing errors in measurement. Tube and pressure leads to register and recorder should be cleaned and all leaks taken up. Method of installation of pressure pipes for best operating results are outlined.—*Aug. G. Nolte.*

Manganese Deposit on Water Filter at Breckenridge, Texas. J. B. Hawley and W. S. Mahlie. Eng. News-Record, 90: 834, 1923. Growth of *Crenothrix Manganifera* in force main which stood idle for 3 weeks is believed to be cause of black manganese deposit on filter sand. Water contains about 0.036 p.p.m. of manganese. No further trouble has been experienced since force main continuously in use.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Low per Capita Water Consumption in London. Anon. Eng. News-Record, 92: 159, 1924. Per capita consumption for year ending March 31, 1923, was 42 U. S. gallon. This was a decrease of 1.64 U. S. gallon from previous year. The rate is considered high by "The Engineer," as compared with that of provincial centers.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Studies under Way on Filter Efficiency Limitations. H. W. Streeter Eng. News-Record, 92: 146. 1924. A detailed study of 16 filter plants has been started by United States Public Health Service to determine just how far a supply can be polluted and still be made safe by subsequent purification.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Eductors for Washing the Rapid Filters at Zelienople, Penn. Geo. Hudson Eng. News-Record, 92: 107, 1924. An eductor installed in this plant instead of usual reducing valve on a pressure line, wash-water pump, or high tower wash-water tank, uses two portions of water from clear well to one from high pressure tank. Is economical both in first cost and in cost of installation.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Iodine Water Treatment at Sault Ste. Marie. H. A. Sherman. Eng. News-Record, 92: 105, 1924. NaI was added to the city water supply at rate of 2 pounds per day for two weeks, twice a year. First application was made in August, 1923, when pumpage rate about 3 m.g.d. Object: prevention of goitre.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Typhoid in Chicago. Edit. and Anon. Eng. News-Record, 92: 100–1; 116-121; 1924. Typhoid epidemic last November was waterborne. Laxness by city authorities regarding frequent examination seems evident. Sampling of chlorinated water tri-weekly and of raw water much less frequently, is inadequate to protect city with 3,000,000 inhabitants. State Board of Health recommends employment of sanitary engineer, with adequate laboratory force, to take charge of water supply. Epidemic was caused by heavily polluted Calumet River flowing into Lake Michigan, from which water supply is taken.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Supervision of Water Treatment Plants in Michigan. E. D. Rich. Eng. News-Record, 92: 73, 1924. All filter plants in Michigan maintain their own laboratories. Of 50 chlorination plants, 41 have analyses made regularly. State Board requires installation of facilities for making examinations and as a result, have 50 laboratories making tests for 54 water systems. Typhoid death rate for the State is less than 5.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Chicago's Diversion of Water from the Great Lakes. Anon. Eng. News-Record, 92: 28–31, 1924. Historical review.—*Frank Bachmann.*

Alumina Cement in France. E. C. Eckel. Eng. News-Record, 91: 347–9, 1923. New type of cement, invented about 1908: high in Al_2O_3; resistant to

sea water and sulphate waters; hardens rapidly. French army used it during war for rapid work on gun emplacements and roads. Is replacing Portland cement on road work, where long tie-ups at street intersections must be avoided. In France, output has reached 7 per cent of total Portland output.—*Frank Bachmann.*

Peebles Portable Sandwasher. ANON. Chem. Ind., **43**: 11, 269, March 14, 1924. Uses very low pressure water jet (4–5 pounds); is compact (6 by 4 by 4 feet; weighs 13 cwts.; and when mounted on wheels has overall dimensions of 9 by 4 feet 4 inches and 3 feet high. At 5 pounds pressure, machine will wash 4.15 tons sand per hour, or one ton in 14½ minutes. At three pounds water pressure, 2½ tons per hour can be handled. It is operated by series of water jets, total consumption of water at five pounds pressure being about 800,000 gallons per hour. It consists essentially of four small washing chambers, one behind the other, on an inclined plane, connected at the bottom by a cast iron pipe. The whole rests on steel axle between the wheels. The sand falls from hopper through an oscillating strainer, operated by small water motor, to separate all pebbles and larger particles. The filtered sand then falls into a chamber at bottom of which is a jet which forces sand upward and mixes it with water. Operation depends on principle that dirt and impurities are lighter than sand and are washed out on the stream of water over a wheel to a discharge, while only the heavier sand is carried over to a second chamber. Sand is propelled continuously through the four chambers in succession in this way by a series of clear water jets.—*A. M. Buswell.*

Water Used in Paper Making. ARTHUR S. M. KLEIN. Paper, **29**: 11, 12–13, 1921. From Chem. Abst., **16**: 2223, July 10, 1922. Review of water consumption as determined by various authorities.—*R. E. Thompson.*

The Determination and Separation of Aluminium. GERHART JANDER AND ERWIN WENDEHORST. Z. angew. Chem., **35**: 244–5, 1922. From Chem. Absts., **16**: 2461, August 10, 1922. Usual methods of determining aluminium are slightly inaccurate. Aluminium hydroxide almost invariably remains to appreciable extent when precipitation effected by ammonium hydroxide, ammonium sulfide, ammonium acetate, sodium thiosulfate, potassium iodide-iodate, or diammonium phosphate. Method is described in which aluminium is volatilized as chloride in stream of hydrogen chloride, collected, converted to nitrate, ignited, and weighed as aluminium oxide. Corrections for manganese and magnesium are necessary.—*R. E. Thompson.*

Exact Determination of the Sulfate Radical in Sodium Sulfate. MOTOTARO MATSUI AND SEN-ICHI KIMURA. J. Chem. Ind., (Japan), **24**: 1039-53, 1921. From Chem. Abst., **16**: 2464, August 10, 1922. From comparison of 5 methods it is concluded that minimum errors are obtained with slow method of Allen and Johnston (C. A. **4**: 1955) when corrections are made for barium sulfate in supernatant liquid and barium chloride and sodium sulfate occluded in precipitate, and with method of Johnston and Adams (C. A. **5**: 2456) when corrections are not made.—*R. E. Thompson.*

Recent Developments in Power Production. D. L. Selby-Bigge. J. Iron Steel Inst. (London), adv. proof, 1922, 40 pp.; Iron and Coal Trades Rev. 104: 659–61, 1922. From Chem. Abst., 16: 2561, August 10, 1922. Extensive review and discussion.—*R. E. Thompson.*

Report on Water. J. W. Sale. J. Assoc. Agr. Chem., 5: 379–88, 1922; cf. C. A. 16: 453. From Chem. Abst., 16: 2563. August 10, 1922. Weselzszky method unsatisfactory for bromine but gave good results for iodine. Proposed procedure for small quantities of lead, copper and zinc outlined.—*R. E. Thompson.*

The Frequent Impurity of Distilled Water. A. Richaud. J. pharm. chim., 25: 469–77, 1922. From Chem. Abst., 16: 2564, August 10, 1922. Summary of sources of impurity and methods of testing.—*R. E. Thompson.*

The Determination of Hardness in Water. A. C. Röttinger. Z Ver. Gas-Wasserfach. in Osterreich u. Ungarn, 59: 13–22, 36–9; Wasser u. Abwasser, 15: 205–6, 1921. From Chem. Abst., 16: 2564, August 10, 1922. Titration with 0.02 N. hydrochloric acid recommended for carbonate hardness and titration with potassium palmitate for total hardness, with suitable correction for end-point. Results considered only as approximate.—*R. E. Thompson.*

The Gas Content of the Water of Lake Himmelsdorfer, near Lübeck. Bruno Schulz. Naturwissenschaften, 10: 307–8, 1922. From Chem. Abst., 16: 2564. August 10, 1922. The deeper water of the lake contains 300 p.p.m. hydrogen sulfide, the highest content of any natural water known.—*R. E. Thompson.*

The Movements of Silt in Streams. Zentr. Bauverwaltg. 39: 212–4, 217–20; Wasser u. Abwasser, 15: 215–6, 1921. From Chem. Abst., 16: 2564, August 10, 1922. Differential equations, to express horizontal and vertical velocities in flowing streams, developed. Effect of these currents on turbulence and turbidities discussed.—*R. E. Thompson.*

Commercial Preparation and Use of Fullers' Earth. T. P. Maynard and L. E. Mallon. Chem. Met. Eng., 26: 1074–6, 1922. From Chem. Abst., 16: 2582, August 10, 1922. Property of adsorbing bases gives fullers' earth value as water softener.—*R. E. Thompson.*

The Destruction of Cement by Water and Waste Water. A. Splittgerber. Wasser, 17: 87–9, 1921; Chimie et industrie 7: 942, 1922; cf. C. A. 15: 4044. From Chem. Abst., 16: 2585, August 10, 1922. Action of calcium sulphate and bicarbonate in water on cement, and precautions in disposal of industrial wastes and means of preventing penetration of these wastes into concrete.—*R. E. Thompson.*

Utilization of Compressed Air in Clearing Gas Piping. J. T. Griffin. Tech. Sec. Am. Gas Assoc., 3rd. Annual Convention, 3: 143–60, 1921. From

Chem. Abst., **16**: 2592, August 10, 1922. Compressed air at 1500 pounds pressure used for removing stoppages in service pipes, scale from house heating boilers, and obstructions in drain pipes to sewers.—*R. E. Thompson.*

Boiler Cleaners for Municipal Power Plants. W. F. Schaphorst. Am. City, **26**: 491, 1922; Public Health Eng. Absts., July 8, 1922. From Chem. Abst., **16**: 2747, August 20, 1922. Mechanical methods of removing scale and soot by rotary cutters or vibratory removers recommended. Boiler compounds are warned against, especially those having secret formulas.—*R. E. Thompson.*

Some Boiler-Firing Troubles. Edw. Ingham. Colliery Guardian, **123**: 1417, 1922. From Chem. Abst., **16**: 2770, August 20, 1922. Recommendations (in original) for overcoming black smoke, cinder in exhaust gases, explosive mixtures in flue, down drafts, boiler vibration, and drop in steam pressure with coal as fuel.—*R. E. Thompson.*

Examination of Water for B. Coli. A. Gaal. Z. Unters. Nahr. Genussm., **46**: 37–43, 1923. Chem. & Ind., **42**: 1148a, November 30, 1923. The bacteria in unsterilised water are unfavorable to development of B. coli and become more so with rising temperature. B. coli keep well at low temperatures, and, when afterwards introduced into nutrient media, are even able to overcome bacteria unfavourable to them at higher temperatures. B. coli inoculated into unsterilized tap water disappeared completely on incubation at 37°C. for 24 hours. Cultures of B. coli in distilled water, however, developed well, both when kept in ice-chest and at higher temperatures for 24 hours. Unfavorable effect of higher temperatures only became noticeable after incubation for fifteen days. Experiments with water containing large amounts of salts in solution confirmed these results, development of B. coli at 37° only occuring when water had been sterilized previous to inoculation. Investigation of water samples 19 and 34 days after inoculation showed that those kept at 37°C. were free from B. coli after 19 days, whereas B. coli were well preserved in samples kept in ice-chest, and developed well on subsequent incubation at 37° in agar or bouillon. After 34 days in ice-chest, B. coli seemed to such an extent acclimatised to low temperature that colonies were formed in agar after incubation for 5 days in ice-chest. These experiments emphasise great variability of B. coli and difficulty of detecting it in certain cases. Water is only to be considered free from B. coli when indole, fermentation, and reduction tests have failed, together with all attempts to cultivate B. coli in specific media. Sample should not have been subjected to temperature higher than that of a cool room, or cellar, between time of collection and investigation (H. C. R.)—*A. M. Buswell.*

Safe Water Supplies for Isolated Houses and Small Institutions where Municipal System is not Available. Publication No. 18, Dept. of Health, Canada. 1923, 34 pp. Rural water supplies and methods of guarding against pollution are described. Fluctuations in temperature of ground waters indicate shallow origin. Ordinarily, at depth of 40-60 feet temperature is about 50°F. and

nearly uniform throughout year. Deep ground waters are usually progressively warmer, increase in temperature being approximately 1°F. for each 50–60 feet increase in depth.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Case in Which Winkler's Manganous Process for Dissolved Oxygen is Untrustworthy. J. H. Coste and E. R. Andrews. Analyst, **48**: 543, 1923. Jour. Soc. Chem. Ind., **43**: 2, B. 31, January 11, 1924. Winkler's manganous process gives erroneous results when used to determine dissolved oxygen in ammonium chloride solutions of concentrations M/2 and upwards, as precipitation of manganous hydroxide and its subsequent oxidation are greatly retarded. Gasometric determinations of the dissolved gases by Winkler's calcite and hydrochloric acid process show that ammonium chloride has an effect of the same order as that of sodium chloride in reducing solubility in water of gases of the air (H. C. R.)—*A. M. Buswell.*

Process for the Electrical Purification of Effluents from Dyestuff Factories and Dyeworks. G. D. Frank. G. P. 380, 891, 10.7. 21. Jour. Soc. Chem. Ind., **43**: 2, B. 31, January 11, 1924. Effluent passes alternately through a number of cells in which it is treated with direct electric current, and vessels in which material, precipitated by action of the current, coagulates into larger particles and settles to bottom of vessel (L. A. C.).—*A. M. Buswell.*

The Mechanical or Rapid Filter. Major F. Johnstone Taylor. Water and Water Eng. **25**: 332, September 20, 1923. Essentially a description of the Wheeler filter bottom.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Supply in 1922 (British). Anon. Water and Water Eng., **25**: 320–1, September 20, 1923. Abstract from the 4th Annual Report of Ministry of Health. Low rainfall in May and June gave rise to fears that deficiency of 1921 might be repeated, but year finished 4 per cent above normal rainfall. The Board is endeavoring to formulate a policy on water supplies to secure better quality and lower cost, and to prevent over-lapping. A considerable number of water and sewage schemes have been approved (including 12 activated sludge plants; 10 for agitation, and 2 for aeration) and nearly 41 million pounds sterling have been loaned by the Government. Experiments have been made at the Birmingham Tame and Rea District Drainage Board Works involving settling the sewage in tanks, a short aeration, and then passage through sprinkling filters. Allows 60 per cent purification in aerators. Hope to lower cost of treatment by the combined process.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Softeners in Boiler Practice. W. Scherr. Water and Water Eng., **25**: 297, 335-6, September 20, 1923. Lime soda treatment requires 6 to 8 hours unless warmed to 50–60°C. Efficiency of filter must be watched, and concentration of soluble salts regulated by blowing off. Free $Ca(OH)_2$ is objectionable, but a slight excess of Na_2CO_3 is helpful in acting on Mg. In thermochemical processes it is necessary to prevent re-absorption of gases, especially if some softened water is added to condenser water. Zeolite softening requires

clear water. Distillation is expensive and distilled H_2O likely to corrode metals if absorption of gases is allowed to take place.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Water Supply of the Central Argentine Railway. J. Cochran. Water and Water Eng., **25**: 328–9, September 20, 1923. Supply is derived from area of Old Pampean sea, formerly connected with the Atlantic: contains much mineral matter, and is bad boiler water. Fine mud of Parana river is very troublesome and hard to get rid of. $MgSO_4$ and NaCl cause trouble.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Biochemical Factors in Modern Water Purification. Gilbert J. Fowler. Water and Water Eng., **25**: 359, October 20, 1923. (Paper read at Mysore Eng. Assn. Conference, Bangalore, 1923.) Aeration of waters is advocated as means of oxidizing food material and keeping down increase of bacteria, possibly inhibiting growth of algae and removing volatile impurities. Efficiency of French non-submerged filters has not received deserved attention. Similarity in principle between water and sewage purification processes emphasized. Aeration alone, in presence of a suitable nidus, or "scaffold," has been shown to be an effective process in the case of the Yangtsze river and the author's activated silt process. (Fowler and Deo, J. Indian Inst. Sci. **2**: p. 9.) Oxidation of organic matter in wells by $KMnO_4$ and removal of bacterial food has been shown to be effective in preventing multiplication of bacteria.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Silt Separation at Diversion Works. F. V. Elsden. Water and Water Eng., **25**: 368 and 411, October 20 and November 20, 1923. Paper based on Egyptian conditions and the knowledge that (1) in all silt laden streams the heaviest silt is that which is rolled along bed of stream, and (2) quantity and coarseness of silt carried by the stream increase from the top downward. "Skimming regulators" are recommended. These are designed to avoid disturbance and silt-lifting eddies and restrain sandy silts and other coarse material from getting into conduits and other water passages.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Institute for Water-, Soil-, and Air-Hygiene at Berlin-Dahlem. Dr. F. Wilhelmi. Illustrierte Zeitung, **161**: 184, September 6, 1923. A general illustrated article on the work of this famous Institute.—*Jack J. Hinman, Jr.*

Purification of Drinking Water. C. A. Grau. Semana Medica, **1**: 1189, June 28, 1923; J. Am. Med. Assn., **81**: 2068, December 15, 1923. Prepare solutions as follows: Solution A.: potassium iodide, 2 grams; iodine: 8 grams; alcohol, 90 cc.; glycerol, 32 cc. solution B: sodium thiosulphate, 15 grams; alcohol, 40 cc.; glycerol, 5 cc.; water, 45 cc. To 1 liter of water to be treated add 5 drops solution A. Shake. After 20 minutes, add 5 drops solution B and mix. Water is ready for use. Avoid wooden vessels since wood absorbs iodine. Method was designed especially for rural schools where suitable water did not exist.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water and Health. ANON. Chicago Dept. of Health, Monthly Bulletin, 17: (n.s.); October 20, 1923. General review of Chicago's water supply experience. In 1891, Chicago had 175 deaths from typhoid per 100,000 population; in 1922, Chicago had 1 death from typhoid per 100,000. Chlorination started in 1912, but all water was not chlorinated until 1918. Average use is 0.3–0.4 p.p.m. Cl. 6 p.p.m. Cl will not kill *B. subtilis*.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Significance of B. Coli in Water in Relation to Health. W. H. FROST, Nation's Health, 5: 527, August, 1923. A general paper—*Jack J. Hinman, Jr.*

Method of Boiling Drinking Water Used in Camp. C. I. WOOD. U. S. Naval Med. Bull., 19: 166, August, 1923. Illustrated article on installation at Santiago, Dominican Republic, of 4 gasoline drums set on railroad rail and brick support above furnace. Furnace chimney with steam escape pipe for each drum. Boiled water run to metal storage tank. Intend to insert Darnall filter in line between boilers and tank to get rid of silt.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Conservation and Control of Water Resources. J. PARRY. Water and Water Eng., 25: 339, September 20, 1923. Plea for National Trust, to control water shed areas and sources of water supply (in Great Britain). Most of the best areas of sufficient rainfall and elevation have been taken up as virtual monopolies by large municipalities and companies. The underground water situation is also unsatisfactory.—*Jack J. Hinman, Jr.*

The Denis-Foraky Teleclinograph. ANON. Water and Water Eng., 25: 336–9, September 20, 1923. Illustrated article describing an apparatus for determination of deviation of bore holes.—*Jack J. Hinman, Jr.*

Absorption of Atmospheric Cases by Water. J. H. COSTE. Analyst, 48: 433–435, 1923. Chem and Ind. 42: 1244A, December 28, 1923. Graph showing volumes of oxygen and nitrogen at normal temperature and pressure dissolved by 1 litre of water of any salinity from 0 to 20 grams of chlorions per kilogram of water. (W. P. S.)—*A. M. Buswell.*

Schlagdenhaufen's Reaction for Magnesium Salts: Application to Waters. G. MEILLERE. Ann. Falsif., 16: 410–411, 1923. Chem. and Ind. 42: 1244A, December 28, 1923. Test depends on formation of a brown precipitate when solution containing a magnesium salt is treated with alkaline hypoiodite. Ten cubic centimeters of the water under examination is mixed with 2 cc. of 20 per cent potassium iodide solution, and sodium hypobromite solution is added, drop by drop, until the intensity of the color ceases to increase. Excess of hypobromite should be avoided. Color is at a maximum within about 15 mins., and then fades gradually. Comparison with colorations produced by known amounts of magnesium affords means of determining quantity of the metal present. Waters containing carbon dioxide or bicarbonates must be treated with hydrochloric acid and evaporated before test is applied (W. P. S.).—*A. M. Buswell.*

A New Type of Deep Well Pump. ANON. Contract Record, 37: 781–2, 1923. "Axiflo" pump, in which all right angled drives have been eliminated, a form of propellor being employed in place of conventional impellor, is described and illustrated. Advantages claimed are: high efficiency and low operating and installation costs; continuous flow, free from pulsations and noise; very simple and compact, often saving cost of new wells by obtaining more water from existing small well in which larger centrifugal pump cannot be employed.—*R. E. Thompson.*

Treatment of Waters Containing Alkaline Bicarbonates. E. D. GRANT, AND BECCO ENGINEERING AND CHEMICAL CO. E. P. 207, 696, 22.11.22. Chem. Ind., 43: 6, B.112, Feb. 8, 1924. Sufficient calcium sulfate and calcium hydroxide are added to transform the alkali bicarbonate, or any desired proportion thereof, into alkali sulfate, with simultaneous precipitation of lime from the initially formed calcium bicarbonate. The sulfate and hydroxide of lime are preferably added in form of powder, and either may be in excess, according to purpose for which water is to be used (J. H. W.).—*A. M. Buswell.*

Annual Report of the Division of Water and Sewage Disposal. (Columbus, Ohio). City Bulletin, 8: 14–25, April 5, 1924. Average for year, 23.5 million gallons softened and filtered per day, equivalent to 92 gallons per capita per day. Raw water average hardness 265 parts per million. Softened water 95 parts per million. "To reduce the hardness of the water from an average of 265 per million to 95 parts per million 3,246 tons of soda-ash and 5,594 tons of lime were required. The price paid for soda-ash was $30.95 per ton and the price paid for the lime was $10.26 per ton, making the total cost for soda-ash $110,464, and the total cost for lime $59,408; or the cost of the lime and soda-ash per one million gallons of water softened amounted to $19.47." Turbidity reduced from 90 parts per million to 0; color from 24 parts per million to 2. Typhoid rate 4.2 per 100,000; resident typhoid rate 1.2 per 100,000. Further information is furnished on carbonation of softened water; washed fuel gases are found suitable since SO_2 is highly soluble and CO_2, relatively insoluble. Cemented sand diffuser copied from the cemented gravel Toronto filters was used. "The conclusion on results obtained in agitation experiments are given in the following paragraphs. (1) Results of plant operation and laboratory experiments indicate that velocities of 0.3 foot per second do not provide sufficient agitation for the treatment of turbid water or for water softening, but that the velocities do not need to exceed 0.6 foot per second. (2) Coagulation results obtained on turbid water at velocities of 0.6 foot per second can be obtained at lower velocities only by adding an excess amount of coagulant. (3) A short mixing period of 20 to 30 minutes at 0.6 foot per second velocities is more effective than a mixing period of 1½ hours at 0.3 foot per second velocity. (4) Mechanical agitators are less expensive to build, more compact, obviate the necessity of lifting water the extra two or three feet necessary to pass through baffled mixing tanks, and provide greater flexibility and accessibility." Detailed sheets of operation and analytical data are given. The Division of Sewage Disposal takes up four pages for its report; pumping and operating data are given.—*A. M. Buswell.*

Pure Water Supplies. (Extract) Sir Alexander Houston. Plumber and Journal of Heating, 45: 539, 316, December 1, 1923. Review of water supplies of England. Water of almost virgin purity furnished to about one-ninth of population. Deep wells and springs needing no treatment, unless softening or iron removal, supply two-ninths. Water requiring treatment is used by remainder of inhabitants excluding those in London.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Status of Texas Water Supplies. V. M. Ehlers. Texas State Journ. of Medicine, 19: 3, 187, July, 1923. Of 76 surface supplies, 25 are filtered, 29 are given sedimentation treatment, 18 chlorinated, 14 raw; 263 ground water supplies, 19 chlorinated; 12 mixed supplies, 3 filtered, 5 chlorinated, 4 raw water supplies.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Preliminary Data Required for the Intelligent Design of a Water Purification Plant. C. Arthur Brown. Lecture delivered to Operators School, Waco, Tex. Graphic curves of past, present and deductive future of Post Office receipts, bank deposits, water department gross income, population, and water consumption, are used to determine probable future consumption and size of plant required. All available sources of water studied taking cognizance of quality and quantity and engineering difficulties in utilization. Location of intakes and purification plant; cost and maintenance, and public opinion are discussed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Rivers Pollution and Fisheries. Report by Standing Committee on Rivers Pollution, Ministry of Agriculture and Fisheries of Great Britain. Report discusses bearing of sewage on fish life, reviewing briefly developments of sewage disposal. Research experiments to determine effect of various concentrations of polluting materials on fish.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Power Plant Auxiliaries and Their Relation to Heat Balance. A. L. Penniman, Jr. Presented at Convention of A. I. E. E., Phila., Pa., February 4–8, 1924. In central steam plants, efforts to increase over-all economy and ease of operation are responsible for the use of motor-driven auxiliaries receiving power from auxiliary turbo-generators, the exhaust from which is used for heating feed water. Greater economy is possible by bleeding steam from low pressure stages of main unit to heat feed water. Considerable heat is reclaimed allowing a smaller condenser and performance of main turbine is improved due to relieving the congestion of steam in low-pressure stages.—*A. W. Blohm.*

Citrate Utilization by Members of the Colon-Aerogenes Group and Their Differential Characteristics. Stewart A. Koser. Jour. Bacteriology, 9: 1, 59, January, 1924. B. coli of fecal origin can be distinguished from soil organisms through inability of fecal bacteria to multiply in media containing citrate as sole source of carbon; whereas soil bacteria grow luxuriantly therein. At least twenty-three strains of soil organisms which would be considered

positive fecal coli from results of methyl red test, may be proven non-fecal through their ability to grow and multiply in media containing 2 grams sodium citrate per litre as only source of carbon. Presence of these strains in soil and their absence from fecal specimens would indicate that sometimes the methyl red confirmation has been responsible for reporting of presence of fecal bacteria, when only soil bacteria were present. The ability to utilize citrates should prove a valuable method of identifying more accurately fecal from non-fecal bacteria. [Perhaps one or more or Mr. Koser's "23 varieties" exist in certain cases on the surface film or deposit inside of water mains, only to be torn loose upon opening fire plugs, etc. Samples collected after flushings or sudden draughts are frequently reported by routine test to contain fecal B. coli, although samples for weeks, or even months, prior to flushing showed consistently absence of colon-aerogenes group.—ABSTR.]—*Linn H. Enslow.*

Corrosion of Steel in Contact with Copper by Natural Waters. W. G. WHITMAN AND R. P. RUSSELL, Ind. Eng. Chem., 16: 3, 276, March, 1924. Corrosion of steel in natural waters is increased wherever it is in contact with other metals more "noble" than itself. Rate of corrosion is dependent upon rate of hydrogen depolarization by dissolved oxygen. Accelerated corrosion of steel in contact with copper is due to increased area available for reaction between dissolved oxygen and hydrogen protective film. As conductivity of solution increases, the copper (or other metal more "noble" than steel) will act as depolarizing surface over increasing distances from the steel, thereby resulting in intensified corrosion. Experimental work indicated a rapid rate of corrosion during first few days. After fourth day, rate had fallen to a constant value which then held for remainder of test. Local corrosion is increased and severe pitting results, where steel is in contact with more "noble" metals. This can be attributed to increased "effective" surface for hydrogen-depolarization.—*Linn H. Enslow.*

Soluble Aluminum—Hematoxylin Test for, in Filtered Water. WM. D. HATFIELD. Ind. Eng. Chem., 16: 3, 233, March, 1924. Satisfactory tests for presence of soluble aluminum in waters through use of hematoxylin may be had only within comparatively narrow zone of hydrogen-ion concentration; viz., pH 8.0-8.5. The hematoxylin-alumina color compound will not form below pH 6.0: above pH 8.5, the color fades rapidly. Between pH 6.5 and 7.5 a relatively permanent, but slow forming, color develops. Waters adjusted to pH 8.0 to 8.5, if containing soluble aluminum, will produce a blue color, which upon acidification with 30 per cent acetic acid, changes to a purple. The excess hematoxylin present changes to yellow, thereby presenting variations from yellow through brown to purple, depending upon quantity of aluminum present and excess of indicator. The improved procedure calls for buffering 50 ml. water with 1 ml. saturated ammonium carbonate (aqueous) solution, to obtain a pH of 8.2±. Add 1 ml. of 0.1 per cent (aqueous) hematoxylin solution, mix, and allow 15 minutes contact for color development. Acidify with 1 ml. 30 per cent acetic acid and compare with standards of known aluminum content treated in like manner.—*Linn. H. Enslow.*

Phenol-Chlorine Water Pollution. Edw. F. Kohman. Ind. Eng. Chem., 15: 5, 518, May, 1923. A 500-ton capacity coke plant, discharging wastes into lake which feeds river of 520 to 820 cubic feet second average flow, caused trouble at a canning plant 6.5 miles distant. Chlorinated city water used in cannery imparted medicinal taste to canned peas, pears, etc. Water containing phenol (1 part to 750 million) after chlorination produced more pronounced and altogether different taste than was obtained by dissolving prepared chlor-phenols in higher concentrations (1 part in 1–50 millions). Phenol in greater concentration than 1 in 50 millions after chlorination produces taste like that of solutions of prepared chlor-phenols. A *small excess* chlorine completely destroys phenolic taste and odor at above dilutions.—*Linn H. Enslow.*

Bacteria in Tannery Soak Waters—Effect of Salts Upon Counts. J. A. Wilson and C. J. Vollmar. Ind. Eng. Chem., 16: 4, 367, April, 1924. Standard nutrient agar (pH 6.9 to 7.1), to which 0.05 mole NaCl per liter was added, produced eighteen times the number of colonies obtained on same medium unsalted, when each was plated out with tannery soak liquors. Other salts produced similar results. KCl (0.1 mole); Na_2SO_3 or $CaCl_2$ (0.025 mole) per liter compared favorably with 0.05 mole NaCl per liter. Increase in concentration over the figures given above for each salt resulted in rapidly decreased counts. Apparently, small amounts of salt will increase dispersion of bacteria, whereas larger amounts will result in agglutination. Increasing period of incubation above 24 hours gave no increase in number of colonies per plate. Count is also dependent upon degree of agitation. Vigorous shaking for five minutes produced a count eight times that from a shaking of only 15 seconds.—*Linn H. Enslow.*

Corrosion of Steel Immersed in Water—Effect of Alkaline Solution on. F. N. Speller and C. R. Texter. Ind. Eng. Chem., 16: 4, 393. April, 1924. In clean steel pipe, initial rate of corrosion is nearly independent of alkalinity of water within certain limits; but at 150°F., rate rapidly decreases for an hour or so until a protective film of ferric-hydroxide has been built up and a state of equilibrium established. At this point, alkalinity has an inhibiting effect upon corrosion. The film formation is apparently of greater importance than the decreased hydrogen-ion concentration. The hydroxyl-ion is the important factor in protecting steel against corrosion, and not the deposition of a protective coating of calcium, etc. as has been previously assumed. At 150°F., 0.12 grams per litter (7 grains per gallon) of NaOH reduced rate of corrosion practically as satisfactorily as higher concentrations. The protective ferric-hydroxide film will not last long when water without alkali is again run through the pipe.—*Linn H. Enslow.*

Quantitative Determination of Iron in Iron Removal Plants. J. H. Linschoten. Water en Gas, 8: 195, 1924. Arrangement of an experimental iron-removal plant is briefly described. Water passes first through coke trickler; then through preliminary filter; it is then distributed between two final filters, one of coarse, the other of fine sand. For control purposes, samples are taken of: (1) raw water, (2) coke trickler effluent, (3) preliminary

filter effluent, (4) coarse sand final filter effluent, and (5) fine sand final filter effluent. Determinations are made of CO_2, HCO_3^-, Fe^{++}, Mn^{++}, both locally and at Central Laboratory (excepting that Mn is not locally determined). Local iron determinations were formerly carried out as follows: add N × 0.1 NaOH; shake in bottle to oxidize ferrous iron to ferric; add N × 0.1 HCl to neutralize both natural alkalinity and NaOH added; measure volume; to 100 cc. add 1 cc. dilute (1:5) HCl, to bring all iron into solution; determine colorimetrically as usual with KCNS, making comparison standards equally acid with sample. Results are satisfactory except when appreciable amounts of organic matter are present; when this happens, a miniature-scale laboratory method has been found preferable: 10 cc. of water are cautiously evaporated to dryness in small porcelain dish with HCl and $KClO_3$; residue is taken up with 1 cc. dilute HCl and distilled water, transferred to small flat-bottomed graduated tube, treated with 1 cc. KCNS, made up to 10 cc., and compared with standards in similar tubes, similarly acidified. In this way interference by protective colloids is avoided. Results given show method to be satisfactory. It is recommended for adoption in all cases. Comparative tables exhibit clearly results obtained on numerous samples by the different methods.—*A. Massink.*

NEW BOOKS

Surveillance des Eaux Pendant L' Année, 1922. M. F. Dienert. This annual publication deals with inspection and supervision of sources, collection, transportation and purification of Paris water supply. Present volume gives rather complete data on rainfall, temperature, electrical resistivity, turbidity, biology, and chlorination. Sanitary surveys and bacteriological findings are also reported. A new filter plant at Ivry was put into operation during 1922. Water is sand filtered and subjected to chloramine treatment. The chlorine addition averaged 0.27 mg. per liter during 1922. The ratio of ammonia to chlorine added, as chloramine was formed, constant at 1 to 40. At purification works of St. Maur, filtration and javellization at rate of 0.35–0.65 p.p.m. of chlorine are used. This kills B. coli and pathogens, but allows sporulating species to live. Water, on its arrival at distribution reservoirs, is completely dechlorinated, in some cases by several treatments, with thiosulfate. As an added protective measure, an aquarium is maintained at the reservoirs, since fish are extraordinarily sensitive to free chlorine. In tracing sources of supply of swamps of Larchant, fluoresceine was used as an indicator. In the dry season, this dye, put into the swamp waters, was soon found in nearby water supplies, some appearing 8 kilometers away in 9 days. The greater part of report deals with bacteriological analysis of water. The chief of the department raises several questions as to purpose and importance of such analyses, especially with reference to pathogen detection. Media and methods in use in Paris are described, and characterizations of the more important colon bacteria are given in some detail. Requirements of a good filtered water supply are outlined.—*A. M. Buswell.*

The Sanitation of Bath Houses. Gerhard, Wm. P. New York; Wm. T. Comstock Co. 16 pp. $0.60. Reviewed in Municipal Engineering, 72: 694, 1923.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

London Water Supply: Annual Report, 1922-3. Municipal Engineering, 72: 697, 1923. Surveyor 64: 506, 1923. Board supplied during the year 88,881.0 million gallons direct to consumer and 683.1 million gallons to other water authorities; daily averages of 241.64 and 1.87 million gallons respectively. The per capita consumption daily was 35.07 gallons.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Analyse et Essais des Materiaux de Construction. Chimie et Physique Appliquées aux Travaux Publiques. J. Mallette, chef du laboratorie de chimie a l'Ecole nationale des Ponts et Chausees, 2nd edition, 14 × 22 cm., 916 pages, 189 fig., Dunod, editeur, Paris, 54 francs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Wasserversorgung und Abwasserbeseitigung. Wilhelm Clar. Potsdam and Leipzig; Bonnez und Hachfeld. M. 3.25. 24 pp. From Chem. Abst., 16: 2566, August 10, 1922.—*R. E. Thompson.*

Grundlagen der Wasserwirtschaft. Wilh. Halbfasz. Berlin: Gebr. Borntrager, M 32. 154 pp. Reviewed in Gas u. Wasserfach, 65: 13, 1922. From Chem. Abst. 16: 2566, August 10, 1922.—*R. E. Thompson.*

Erdsalzgehalt des Trinkwassers und Kariesfrequenz in der Schweiz. Walter Paul. Zurich: Berichthaus. 39 pp. From Chem. Abst., 16: 2566, August 10, 1922.—*R. E. Thompson.*

Kalender fur das Gas- und Wasserfach. E. Schilling and G. Thiem. 2 parts. München: Oldenbourg. In pocket form, M. 50. Reviewed in Gesundh. Ing., 45: 192, 1922. From Chem. Abst., 16: 2597, August 10, 1922.—*R. E. Thompson.*

Outline of Ground-Water Hydrology with Denfiitions. Oscar E. Meinzer. U. S. Geological Survey, Water Supply Paper 494, 1923. This paper gives a very complete outline, with definitions, of the numerous terms employed in ground water hydrology, including atmospheric water, surface water and subsurface water. Diagrams and maps illustrate many of the terms.—*A. W. Blohm.*

The water works pumping station of the City of Allentown, Pa., is described in an illustrated leaflet issued by the De Laval Steam Turbine Company, of Trenton, N. J. The water supply for the 85,000 inhabitants is taken from two springs, one located near the pumping station and the other at a distance of 5 miles, is supplied to 19,000 connections at a single family rate of $3.75 net per year. The pressure varies from 40 to 100 pounds. The principal pumping equipment consists of two centrifugal pumps designed to be driven either by steam turbine or by an electric motor using purchased electric power, the units being mounted upon an elevated platform above flood level, so that the pumps can continue to operate in case the steam supply fails due to flooding of the pumping station.